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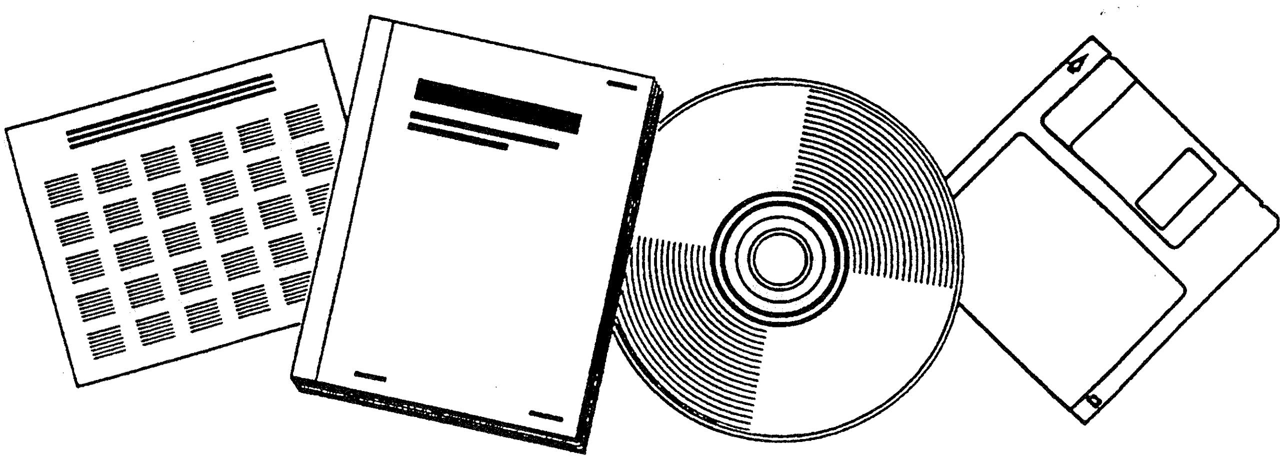
CHARACTERIZATION OF MARINE MAMMALS AND TURTLES IN THE MID- AND NORTH ATLANTIC AREAS OF THE U.S. OUTER CONTINENTAL SHELF

CetAP

RHODE ISLAND UNIV., KINGSTON

DEC 1982



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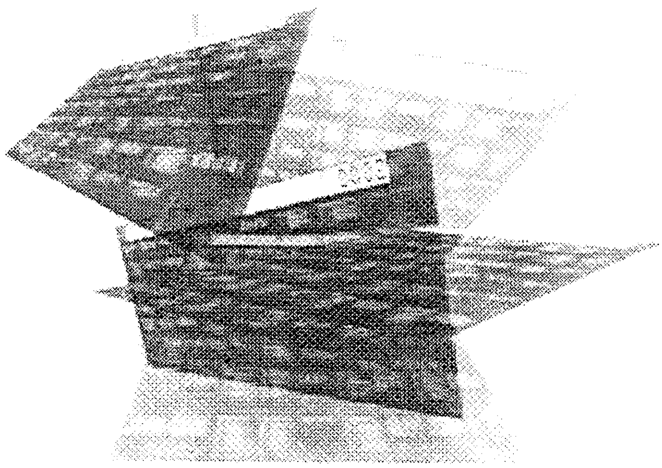

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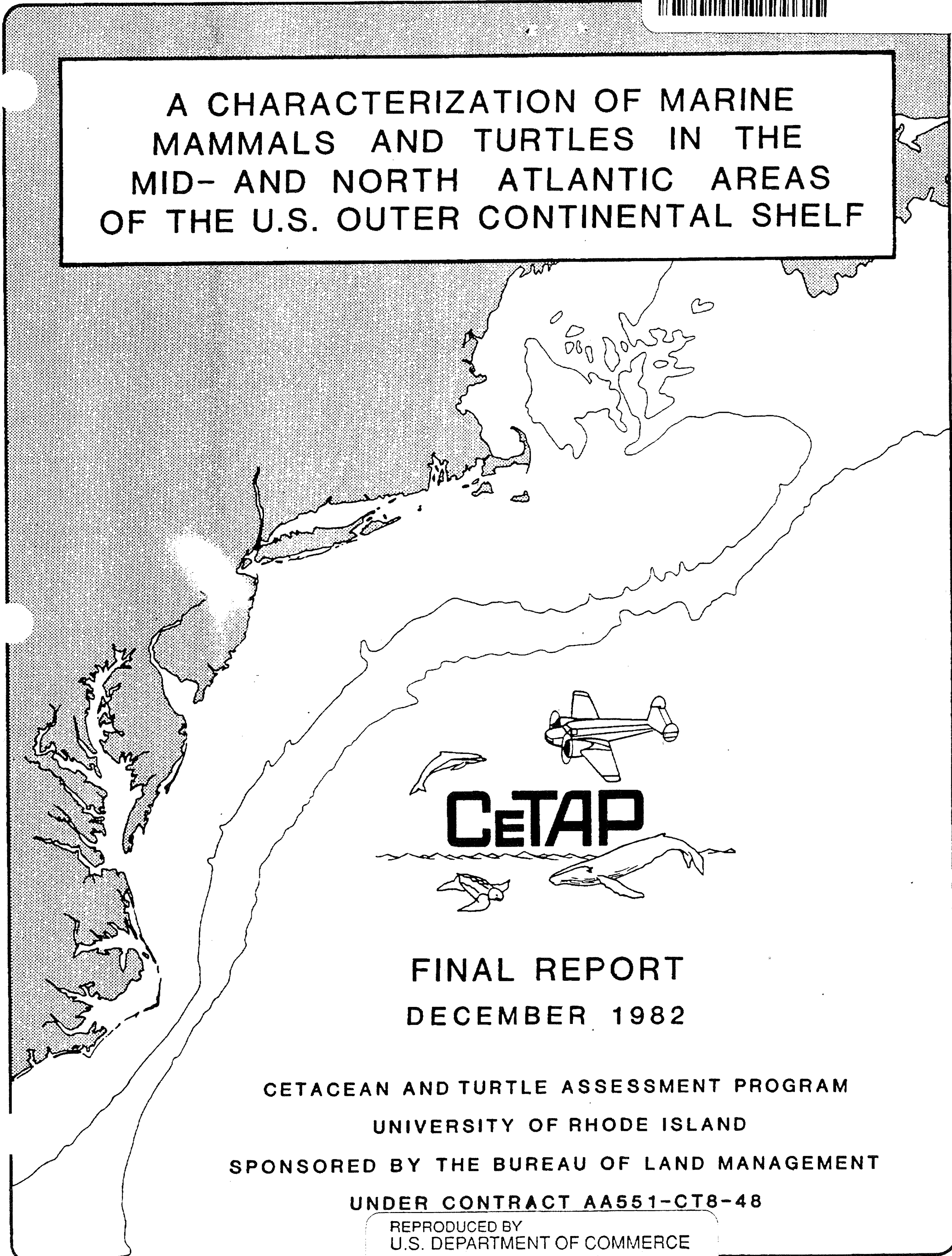

FINAL REPORT

DECEMBER 1982

CETACEAN AND TURTLE ASSESSMENT PROGRAM

UNIVERSITY OF RHODE ISLAND

SPONSORED BY THE BUREAU OF LAND MANAGEMENT

UNDER CONTRACT AA551-CT8-48

A CHARACTERIZATION OF MARINE MAMMALS AND TURTLES IN THE MID- AND NORTH ATLANTIC AREAS OF THE U.S. OUTER CONTINENTAL SHELF

Final Report
of the

Cetacean and Turtle Assessment Program

University of Rhode Island
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December 1982

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Prepared for:

U.S. Department of the Interior
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18th and C Street, NW, Room 2455
Washington, DC 20240

Under Contract AA551-CT8-48

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Preface

In the 39 month period from 1 November 1978 through 28 January 1982, the Cetacean and Turtle Assessment Program surveyed over a quarter of a million miles of trackline and made over 11,000 sightings of marine mammals and 2,800 sightings of marine turtles. The goal of these studies was to characterize marine mammals and turtles in the Mid- and North Atlantic regions of the U.S. Outer Continental Shelf. These results are intended for use in decision-making relative to oil and gas exploration and development in these regions. This CETAP Final Report presents the cumulative and summarized results from this study.

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CHAPTER I

INTRODUCTION

GENERAL REMARKS/PROGRAM HISTORY

The Cetacean and Turtle Assessment Program (CETAP) began at the University of Rhode Island in June of 1978. Under contract to the Bureau of Land Management, field studies began in November of 1978. Annual Reports were prepared summarizing the findings of 1979 and 1980 respectively. Field studies were concluded in January of 1982. This document is the third and final report of the program.

The program objectives were:

1. To determine which species of marine mammals and marine turtles inhabit and/or migrate through the study area;
2. To identify, delineate, and describe areas of importance (feeding, breeding, calving, etc.) to marine mammals and marine turtles in the study area;
3. To determine the temporal and spatial distribution of marine mammals and marine turtles in the study area;
4. To estimate the size and extent of marine mammal and turtle populations in the study area;
5. To emphasize the above items (1-4) for those species classified as threatened or endangered by the Department of Interior and Department of Commerce.

The study area (Figure 1) was defined to be the waters overlying the U.S. Outer Continental Shelf (OCS) between Cape Hatteras, North Carolina, and Nova Scotia, Canada. Inner and outer boundaries were established: the contiguous coastline, and five nautical miles (n.mi.) seaward of the 1000 fathom depth contour shown on U.S. National Ocean Survey navigational chart No. 13003. The size of this study area is approximately 81,154 square n.mi. The study area is characterized by many submarine canyons, shoals, submarine banks, diverse depth gradients, proximity to a major ocean current (the Gulf Stream), numerous adjoining bays and sounds, and a large semienclosed body of water--the Gulf of Maine. Numerous location names used throughout this report are illustrated on Figure 2 and described in the glossary immediately following.

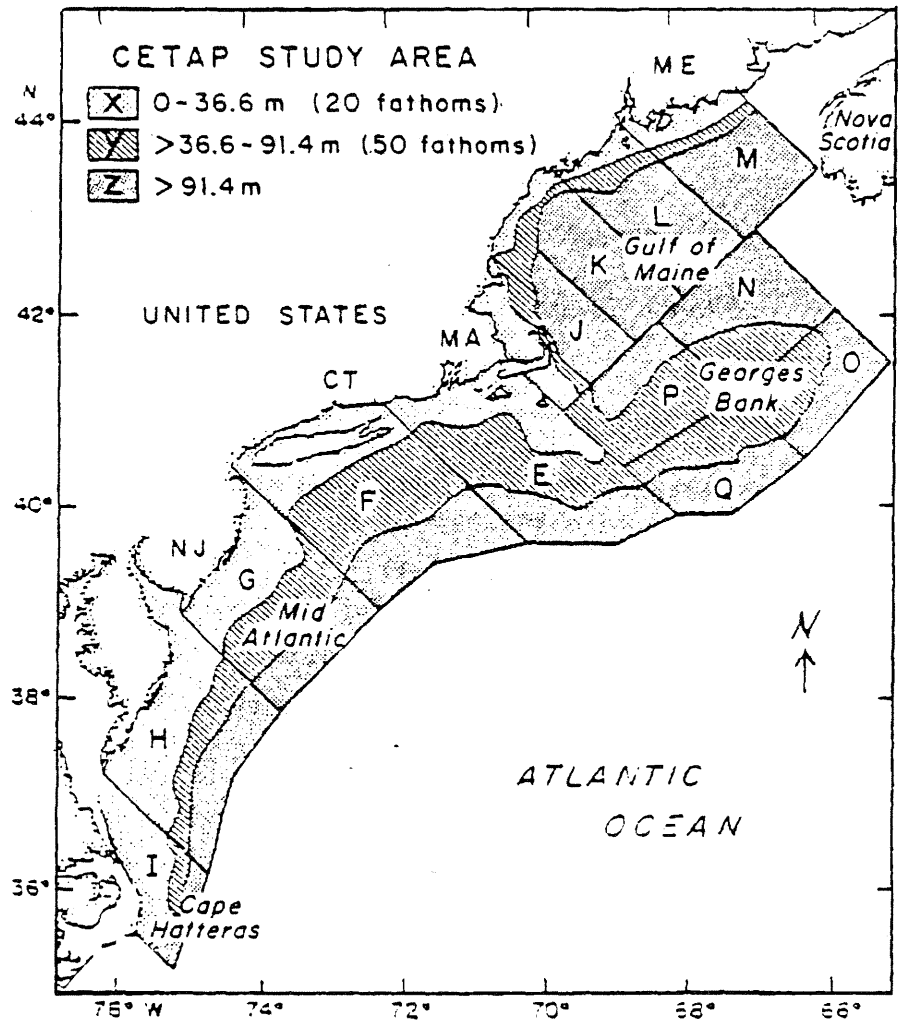

Figure 1. The CETAP study area encompasses 81,154 n.mi.^{2} (278,350 km^2) of the U.S. Outer Continental Shelf between Cape Hatteras, North Carolina, and Nova Scotia, Canada. Additional boundaries are the coastline and a line parallel to, and five nautical miles (9.3 km) seaward of, the surface projection of the 1000 fathom (1830 m) isobath. No bays or sounds are included within the study area. Capital letters are sampling block designators. The sampling area was stratified on the basis of depth zones (strata x, y, and z) representing the nearshore (0-36.6 m (20 fathoms)), shelf (> 36.3-91.4 m (50 fathoms)), and slope (> 91.4 m) regions. The strata are illustrated in three different shadings.

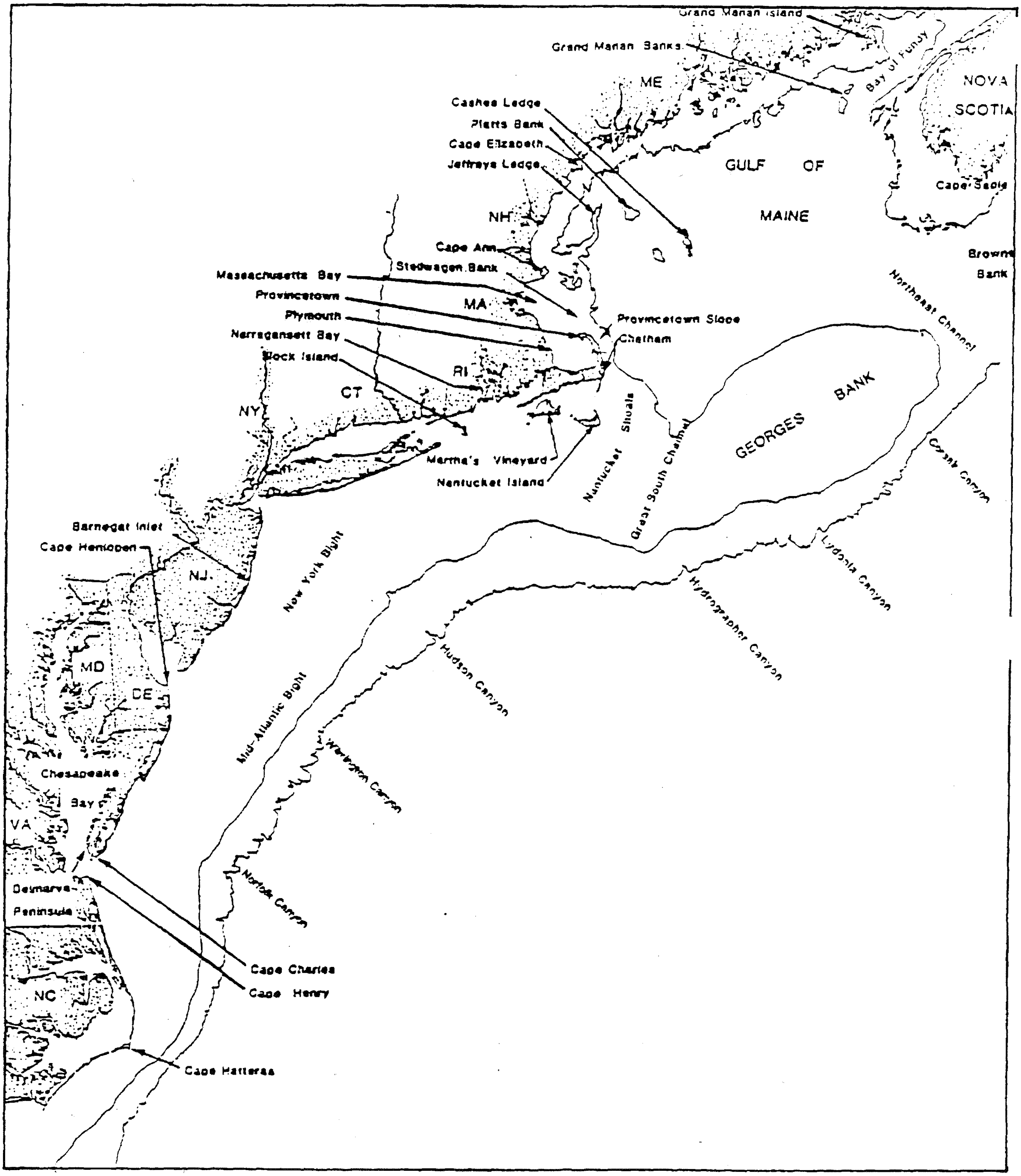

Figure 2. The study area showing geographical place names referred to in the text. A glossary of terms immediately follows this page.

GLOSSARY OF GEOGRAPHICAL TERMS

Barnegat Inlet - the pass to Barnegat Bay, halfway between Atlantic City and Sandy Hook, New Jersey

Bay of Fundy - body of water located between New Brunswick and Nova Scotia, Canada

Block Island - a small island 12 miles south of Point Judith, Rhode Island

Browns Bank - a bank on the continental shelf 50 miles due south of Cape Sable, Nova Scotia

Cape Ann - the northernmost cape on the coastline of Massachusetts

Cape Charles - the northern cape at the mouth of the Chesapeake Bay

Cape Cod - the hook-shaped peninsula of southeastern Massachusetts

Cape Elizabeth - a point of land 10 miles SSE of Portland, ME

Cape Hatteras - major cape of the eastern seaboard located at 35° 15'N, 75°30'W

Cape Henlopen - the southern cape at the mouth of the Delaware Bay

Cape Henry - the southern cape at the mouth of Chesapeake Bay

Cape May - the northern cape at the mouth of Delaware Bay

Cape Sable - the southern most point of Nova Scotia

Chappaquidick - an island on the east end of Martha's Vineyard, MA

Chatham - a coastal town on the SE shore of Cape Cod, MA

Corsair Canyon - a canyon in the continental shelf east of Georges Bank; the coordinates are 37°30'N, 74°30'W

Delmarva Peninsula - the peninsula between the Chespeake and Delaware Bays

Georges Bank - large bank on the continental shelf east of Nantucket Shoals

Georges Basin - the basin off the northern edge of Georges Bank, located in the Gulf of Maine, and the shoreward extension of the Northeast Channel

Grand Manan Banks - an area of shoal water in the mouth of the Bay of Fundy adjacent to Grand Manan Island

Grand Manan Island - an island 7 miles from the border between Maine and New Brunswick, Canada

Great South Channel - a deep water channel which runs from south to north across the OCS, midway between Nantucket Shoals and Georges Bank

Gulf of Maine - gulf bounded by Massachusetts, New Hampshire, Maine, and Nova Scotia

Gulf of Maine Funnel Basin - a funnel-shaped region defined by the Nantucket Shoals and Provincetown slopes on the west and by the western slope of Georges Bank on the east. The funnel basin connects the waters of the Gulf of Maine to the Atlantic Ocean through the Great South Channel

Gulf of St. Lawrence - a body of water bordered by Quebec, New Brunswick, Nova Scotia, and Newfoundland, Canada

Hudson Canyon - a canyon in the continental shelf 100 miles SE of New York City, New York, the coordinates are 39°30'N, 72°14'W

Hydrographer Canyon - a canyon in the continental shelf at the southern end of the Great South Channel; the coordinates are 40°05'N, 69°01'W

Jeffreys Ledge - a ridge in the ocean floor northeast of Cape Ann, MA

Lydonia Canyon - a canyon in the continental shelf south of Georges Bank; the coordinates are 40°28'N, 67°41'W

Martha's Vineyard - an island 7 miles south of Cape Cod, MA

Massachusetts Bay - the body of water east of Boston, MA, between Cape Cod and Cape Ann, excluding Cape Cod Bay

Mid-Atlantic Bight - the body of water found inshore of an imaginary line between Cape Cod and Cape Hatteras, NC

Montauk Point - the easternmost point of Long Island, NY

Moriches Inlet - a pass in the barrier beach on the southeast portion of Long Island, NY

Nantucket Island - an island about 25 miles south of Cape Cod, MA

Nantucket Shoals - the area of shoal water directly east and south of Nantucket Island

Narragansett Bay - the principal bay of Rhode Island

New York Bight - the body of water found inshore of the imaginary line between Cape May, NJ, and Montauk Point, Long Island, NY

Norfolk Canyon - a canyon in the continental shelf approximately 75 miles due east of Cape Charles, VA; the coordinates are 37°05'N, 74°40'W

Northeast Channel - a deep water channel running from west to east approximately 80 miles southwest of Nova Scotia. It separates Georges and Browns Banks

Platts Bank - a bank approximately 40 miles southeast of Cape Elizabeth, ME

Plymouth - a coastal town about 35 miles south of Boston, MA

Provincetown - the coastal town on the northern tip of Cape Cod, MA

Provincetown slope - the area characterized by a sloping bottom east of Cape Cod, MA

Quincy - a coastal suburb about 7 miles south of Boston, MA

Reynolds Channel/Rockaway Inlet - a pass in the barrier beach of southwestern Long Island, NY

Stellwagen Bank - a bank extending from 5 to 30 miles north of Provincetwon, Cape Cod, MA

Wilmington Canyon - a canyon in the continental shelf approximately 100 miles southeast of Atlantic City, NJ; the coordinates are 38°30'N, 74°30'W

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CHAPTER II

METHODOLOGY

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DATA COLLECTION

The third and final year of CETAP studies took place in 1981. Much of the methodology described in the 1979 and 1980 CETAP Annual Reports was continued. There were, however, a number of refinements and changes.

In 1981 there were four principal changes to the field studies program and corresponding data collection: (1) The shipboard platforms-of-opportunity program was discontinued at the end of 1980, (2) the sampling within the study area was largely restricted to lease sale areas and areas of known endangered species abundance, (3) a set of replicate samples was taken in order to gauge the variability present in abundance estimation based on aerial survey data, and (4) two additional survey blocks were added (one in the Mid-Atlantic, and one in the North Atlantic) over the continental slope and rise.

The resulting data collection in 1981 was from: (1) four dedicated aerial surveys (including replicate sampling), (2) three endangered species specific surveys, (3) an aircraft-of-opportunity program, (4) a dedicated cruise studying respiration and dive time behavior in the Cape Cod area, and (5) opportunistic data contributed by a number of sources. The sections below summarize the 1981 sampling.

Dedicated Aerial Surveys

The four dedicated surveys in 1981 were flown as follows:

I	20 April - 20 June	17 flight days
II	15 July - 15 August	10 flight days
III	15 October - 15 December	7 flight days
IV	2 January - 31 January 1982	2 flight days

The blocks surveyed are shown in Figure 3. The replicate sampling took place in the North Atlantic areas in the spring survey. All methodology was identical to that of previous years and is described in detail in the 1979 and 1980 CETAP Annual Reports.

Platforms-of-Opportunity Program

As described, the shipboard platforms-of-opportunity program was discontinued at the conclusion of the 1980 field studies. The aircraft-of-opportunity portion of the program was continued, and was conducted between February and October of 1981. As before, this aspect of the program utilized exclusively the Coast Guard aircraft based at Air Station Cape Cod. Methodology was identical to that of previous years.

Opportunistic Data

Sighting data collected and reported by other researchers, pilots, fishermen, yachtsmen, mariners, and shore-based observers continued to be utilized in 1981. As in previous years, standard formatting and quality control procedures took place prior to merging with the CETAP data base.

Species Specific Surveys

Three endangered species specific surveys were conducted in 1981. The dates and days flown were:

I	8-19 May	6 flight days
II	9 July	1 flight day
III	26 August - 14 October	7 flight days

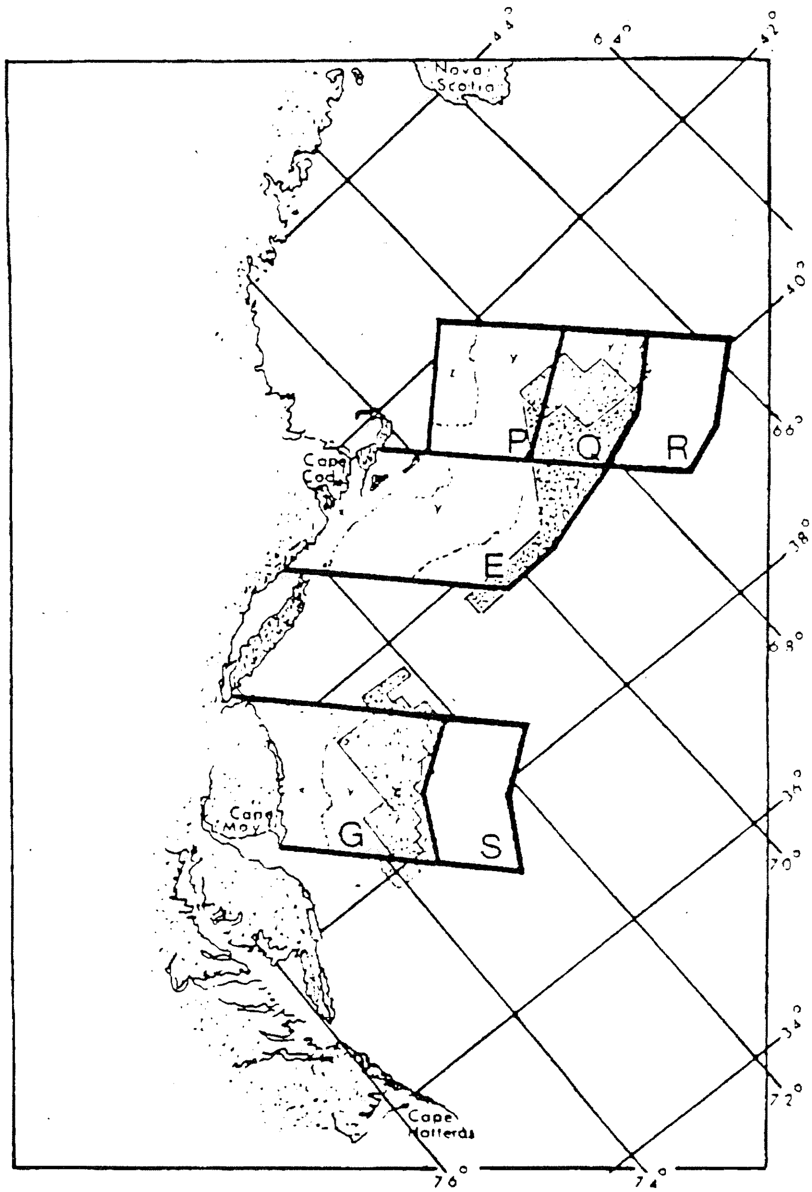

Figure 3. CETAP main aerial survey blocks for the 1981 sampling. Blocks R and S were new to the study area this year, and are located in areas of future proposed leasing activity over the continental slope and rise region. Stippled areas are present and proposed BLM lease sale areas.

These flights took place in the northern Gulf of Maine and southwestern Nova Scotia area, as well as east of Cape Cod (Figure 4). These flights were designed primarily to obtain data contributing to a better understanding of the northern distribution and migration of the right (Eubalaena glacialis), the humpback (Megaptera novaeangliae) and the fin whale (Balaenoptera physalus). Data on other species was collected in the standard manner in the course of these surveys. The methodology was identical to previous years.

Dedicated Cruise

A dedicated cruise aboard the R/V Tioga took place from 9-30 May 1981. The area of operations included Stellwagen Bank and the Great South Channel area, east of Cape Cod. The object of the cruise was twofold: (1) Study behavior, respiration, and submergence time of three endangered large whales--right, humpback, and fin whales, and (2) Cooperative participation in a multi-agency, NASA coordinated, remote-sensing and ground-truthing study--the Nantucket Shoals Experiment.

Operations were coordinated with CETAP aerial surveys for the purpose of reconnaissance and identifying locations and concentrations of cetaceans for study.

Environmental data and chlorophyll and plankton samples were taken at 95 stations. There were 45 hours of behavioral observations recorded on endangered species in a total of 35 different sessions. Behavioral data collection procedures are described in detail in the 1980 CETAP Annual Report and in Special Topic D in this report.

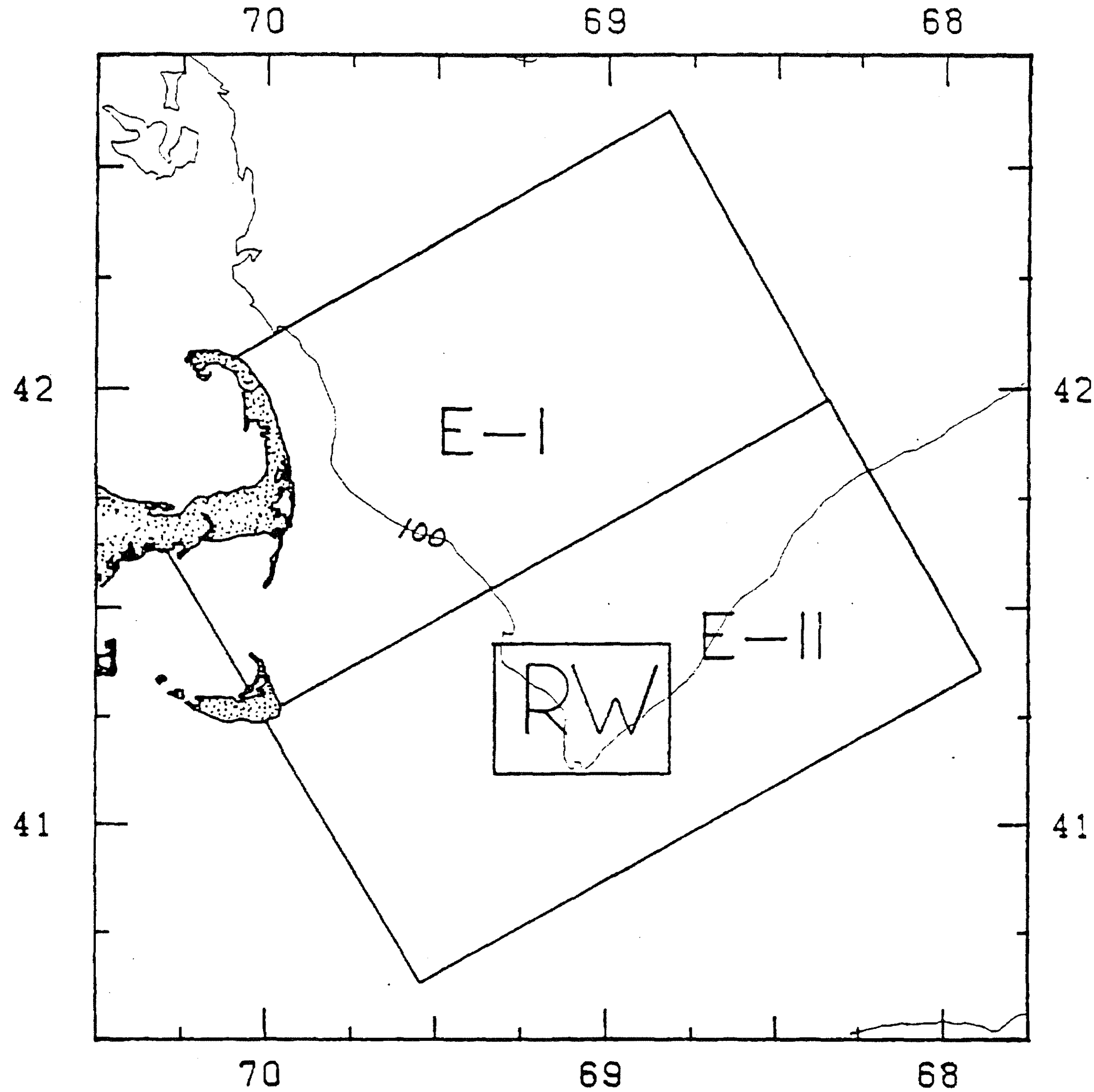

Figure 4. CETAP endangered species survey blocks, 1981. Blocks E-I and E-II were sampled by the Cessna 337 Skymaster, and Block RW was sampled by both the Skymaster and the AT-11.

TIME FRAME DEFINITIONS FOR DATA COLLECTION AND ANALYSIS

Over the course of the three year field studies program, CETAP has employed a number of sampling schemes and time intervals for data collection and analysis. In this final report, all data are presented in one of two ways: (1) Total cumulative data for all 39 months of sampling--1 November 1978 through 28 January 1982, or (2) Seasonal. The definitions used here follow the astronomical or calendar seasons, and are:

Spring	March 20 through June 20
Summer	June 21 through September 21
Fall	September 22 through December 20
Winter	December 21 through March 19

DATA MANAGEMENT

In 1981, the data management system continued unchanged from that of 1980. Basically, the data base system uses the SAS (Statistical Analysis System) software package, the University of Rhode Island's NAS 7000N mainframe computer, a secondary Prime 750 computer, and a Zeta 53 plotter.

DATA SYNTHESIS AND ANALYSIS

Distributions Over Time and Space

The basic data product for analysis of cetacean and turtle occurrence continues to be computer-generated plots of sightings--either cumulative or by season. Details as to bathymetric features or lease sale boundaries are provided through use of the transparent overlays located in the rear pocket of the report.

The distributional data and the resulting conclusions from them are strongly influenced by sighting effort. This factor is addressed in both of the following subsections.

Sighting Effort

While surveys are often planned to uniformly distribute effort over a given space and time, weather, logistical constraints, and other factors often result in a non-uniform distribution of effort. The sighting data have been shown to be highly correlated to the sighting effort which produced the data (Hain et al., 1981), thereby introducing a substantial bias.

CETAP has continued to investigate and refine the way in which effort is taken into account. In this final report, the geographical unit for analysis of sighting effort is the 10' quadrat (1370 in the study area) and the time interval is either total cumulative or seasonal. The sighting effort per unit area is shown as a three-dimensional plot of number of events per 10' quadrat. The term "event" denotes the discrete instance at which a standard time/position mark is recorded along the trackline. It is a convenient measure of sighting effort which is highly correlated to both miles on watch or hours on watch. It is particularly useful because of ease of computation and analysis. The trackline mileage is also used as a sighting effort measure in certain instances. The details of this methodology are given in the 1979 and 1980 CETAP Annual Reports.

Relative Abundance: The Distributional Data Corrected for Sighting Effort

In the 1980 CETAP Annual Report and in this Final Report, raw sighting data have been adjusted for sighting effort to produce relative abundance values. This method provides an improved picture of the actual species distribution over space and/or time, since the bias introduced by varying sighting effort has been removed. The resulting individuals-per-unit effort measure is analogous to the catch per unit effort (CPUE) indices employed in the fisheries sciences.

As in the analysis of basic sighting effort, CETAP has investigated and refined various methods of relative abundance analysis. Here again, a single and best method has been chosen for this report. This method uses three-dimensional plots of numbers of individuals divided by number of events (the relative abundance) for each 10' quadrat.

The details on the methodology and the simplifying assumptions are given in the 1980 CETAP Annual Report. The 3-D plots were generated through the SYMAP and ASPEX routines maintained by the Academic Computer Center at the University of Rhode Island and developed by the Harvard Graduate School of Graphics Design.

Population Estimation Analysis

Over the course of the three year CETAP program there have been a number of refinements in the way in which population estimates have been calculated. These refinements were based on an evolution of methods and aimed at increasing precision through decreasing the size of the variance terms. In the 1979 Annual Report, the method used was the Cox-Eberhardt non-parametric method (Eberhardt, 1978). In the 1980 Annual Report, calculations were based on the methods of Burnham et al. (1980). In this final report, the methods of Burnham et al.

(1980) were continued but with the modification of using mean pod size x number of sightings rather than number of individuals to calculate the density of individuals on a given trackline. The current method of estimation is described below.

As in 1980, estimates of animal density and abundance were made using line transect analytical techniques. From Burnham et al. (1980) density estimates ($\hat{D}_t$) take the form:

$$\hat{D}_t = \frac{n_t \hat{f}(0)}{2L_t}$$

where L_t is the length of transect sampled, n_t the number of targets observed along the transect and $\hat{f}(0)$ the estimated probability density function evaluated at a right angle distance of 0.

As described in the 1981 analysis, n_t was taken to be the number of "pods" of cetaceans and/or turtles sighted along transect t (t=1,2,...,n). The average "pod" size was estimated as the average number of animals of a given species observed per sighting from the pooled three-year data base. The estimated density of individuals ($\hat{D}_{It}$) sampled along a given transect was estimated as:

$$\hat{D}_{It} = \frac{\hat{g} n_t \hat{f}(0)}{2L_t}$$

where $\hat{g}$ is the estimated mean pod size.

Since transect lines were treated as replicates within a sampling stratum or block and since the transects were of unequal length, a weighted mean estimate was used for each stratum or block sampled. This estimate takes the form

$$\hat{D}_I = \frac{\sum_{i=1}^{T} L_t \hat{D}_{It}}{\sum_{i=1}^{T} L_t}$$

The variance of this estimate was taken as (from Burnham et al., 1980, as extended by Hay, 1982).

$$V(\hat{D}_I) = \hat{D}_I^{\,2}\left(\frac{V(\hat{g})}{\hat{g}^2} + \frac{V(n)}{n^2} + \frac{V[\hat{f}(0)]}{[\hat{f}(0)]^2}\right)$$

The sampling variance terms for $\hat{g}$ ($V(\hat{g})$) and n ($V(n)$) were empirically derived. The variance term for $\hat{f}(0)$ ($V(\hat{f}(0))$) was the theoretical variance computed from program TRANSECT (Laake et al. 1980) for the "best fit" model estimator of $\hat{f}(0)$.

Burnham et al. (1980) have outlined the selection criteria for choosing the "best fit" model. In this analysis, the most parsimonious model was taken as the "best fit". That is, given a satisfactory fit based on the Chi-square goodness-of-fit, the model yielding the most precise estimate of $\hat{f}(0)$ was chosen. Five different models were fit to the sighting frequency data. These included: Fourier Series, Exponential Polynomial, Negative Exponential, Half Normal, and Exponential Power Series.

Confidence intervals about the density (and abundance) estimates were constructed using the standard student's-t method.

Estimates of species abundance were made as:

$$\hat{N}_I = \hat{D}_I A$$

where A is the entire sampling area (in this case the area of a stratum or block).

The estimates presented for most species are conservative due to, among other factors, animal diving behavior. The estimates presented represent the average number of individuals at the surface, available to be seen at any time. In order to adjust the estimates for animal diving behavior one must consider the probability that an animal will be at the surface at any time.

Given that:

$$P(\text{surface}) = p, \quad 0 \leq p < 1$$

and

$$P(\text{sighting} \mid \text{at surface}, x=0) = g'(0) \equiv 1$$

Then, assuming that the aircraft does not influence the diving behavior of the species sampled,

$$g(0) = P(\text{sighting} \mid x=0) = g'(0) \cdot p = p$$

From Seber (1973) and Burnham et al. (1980).

$$f(0) = \frac{g(0)}{\frac{1}{w}\int_0^w g(x)dx}$$

$$= \frac{g'(0)p}{\mu_w}$$

and

$$\frac{f(0)}{p} = \frac{1}{\mu_w}$$

Also given (from Burnham et al.)

$$\hat{D} = \frac{n}{2L\mu_w}$$

then

$$\hat{D} = S \cdot \frac{nf(0)}{2L}$$

where S is the scale-up factor for adjusting density estimates for diving behavior. By extension of Burnham et al. (1980) and Hay (1981) the variance of this estimate may be taken as:

$$V(\hat{D}) = \hat{D}^2\left(\frac{V(n)}{n^2} + \frac{V[\hat{f}(0)]}{[\hat{f}(0)]^2} + \frac{V(S)}{S^2}\right)$$

Estimation of the scale-up factor may be made from several data sources including aerial (preferred) and shipboard time-series observations and radio-tag data.

Given a time-series observational record of surface and subsurface bout durations, the value of S may be estimated as the first hinge point in the log-survivorship function (log of the frequency of intervals greater than a given time vs time). In the behavioral literature (eg. Fagen and Young (1978) and Special Topic D, this report) the first hinge-point is used as an objective criterion to define interbout intervals. In the case of whales, the bouts of interest are surface and subsurface.

Analytically, the interbout interval may be defined by fitting a mixed exponential model as proposed by Fagen and Young (1978):

$$f(t) = qa_1e^{-a_1t} + (1-q)a_2e^{-a_2t}$$

for $t>0$. Here a_1 and a_2 are the respective negative exponential model parameters and q the weight parameter for the mixed model.

The intersection of the two components is defined as the interbout interval. That is, one must solve for time, t, when

$$qa_1e^{-a_1t} = (1-q)a_2e^{-a_2t}$$

$$t = \frac{\ln(q/(1-q)) - \ln(a_2/a_1)}{a_1 - a_2}$$

The mixed exponential model for estimating interbout intervals may not be adequate for cases where bouts are grouped into "superbouts" (Fagen and Young, 1978). In these cases graphical techniques may yield a more reasonable estimate of the first hinge-point in the log-survivorship function. The data presented in Special Topic D (this volume) suggest that superbouts may be confounding and for that reason graphical methods were used to derive estimates of t.

Time t is interpreted as the time an individual (or pod) spends at (or very near) the surface (surface bout duration) and is available to be seen. Observers in an aircraft are able to scan forward and view a given patch of water for a period of time (t'); therefore, t' must be considered when evaluating the time an animal might be sighted during the plane's passage (e.g., in the fashion of McLaren, 1961). Assuming a random distribution of targets with respect to the viewing field, then the average time a water patch is visible to an observer may be used for adjustment. This average is estimated as:

$$\hat{t}'_s = \frac{1}{f_s(0)v} \sum_{i=1}^{(90-\zeta)>0} \sin \Theta_i \tan \zeta/(90 - \zeta)$$

where t'_s is specific to species s and dependent upon the estimate of f(0) for each species ($\hat{f}_s(0)$), v is the aircraft velocity, Θ_i the angle to water patch i and ζ the angular deviation from 90° of the average viewing field.

The probability that an animal (or pod of animals) is at (or very near) the surface at any time during passage of the aircraft (p) may be estimated from shipboard data, assuming that an animal (or pod) is always visible to aircraft observers during the duration (t) of a surface bout, defined above. An estimate of p is:

$$\hat{p} = \sum_{i=1}^{N} p_i / N$$

where

$$p_i = s_i/(s_i + d_i) = \begin{cases} 1, & \text{when } s_i+d_i \leq t+t' \\ <1, & \text{when } s_i+d_i > t+t' \end{cases}$$

where s_i represents the observed duration of surface bout i and d_i the duration of subsurface bout i.

The scale-up factor (S), is then estimated as

$$\hat{S} = \frac{1}{\hat{p}}$$

with an empirically derived sampling variance.

Sufficient data were only available to estimate the scale-up factor for three cetacean species. Factors were estimated for fin, humpback and right whales.

Regional Estimates

Due to a general lack of synopticity in the samples during any survey period and animal movements, estimates made are strictly valid only for the block and/or stratum sampled on the day the sample was taken. However, reasonable estimates of regional abundance may be achieved using weighted mean estimates from the pooled three year sample partitioned by seasons and specific areas. The seasons used are "calendar" seasons (spring, 20 March-20 June; summer, 21 June-21 September; fall, 22 September-20 December; and winter, 21 December-19 March). The defined regions of interest are shown in Figure 5. The grouping of the sampling blocks in the defined regions are given in Table 1. Average regional/seasonal densities were calculated as the area-weighted mean of all idividual sample densities in that region and season, while the variance term represents the weighted mean of the individual variances. Corresponding abundance and confidence intervals were estimated as above.

Because many of the defined regions contain only specific strata from the sampling blocks and the 1979 data were not stratified, the estimated averages within these regions could not include the 1979 data. It was therefore decided to post-stratify the 1979 data into the same depth strata used for the 1980 and 1981 sampling. The 1979 aerial survey lines were plotted and each event assigned to the appropriate stratum. New events were then interpolated to mark the change of strata along each track line. Sampling blocks C and D were subdivided into 1980/1981 blocks N, O, P, and Q to accomodate the region definition scheme. This was not necessary for blocks A and B (1980/1981 blocks J, K, L, and M). The population estimates were recalculated after merging the data set containing the new 1979 blocks, strata and boundary events with the main data base. The resultant block/stratum estimates were used to calculate the averages

Table 1. Region definitions for estimates of cetacean and turtle stocks.

Region	[a]1980-81 Sampling Blocks	[a]1978-79 Sampling Blocks
Gulf of Maine	J, K, L, M	A, B
Georges Bank	N, O, P, Q	C, D
<50 fathoms	Ny, Oy, Py, Qy	——
>50 fathoms	Nz, Oz, Pz, Qz	——
Lease Sale 52	Q, Ez	——
Mid-Atlantic	E, F, G, H, I	E, F, G, H, I
New York Bight	F, G	F, G
near-shore	Ex, Fx, Gx, Hx, Ix	——
mid-shelf	Ey, Fy, Gy, Hy, Iy	——
Shelf Edge	Ez, Fz, Gz, Hz, Iz, Oz, Qz	——
Continental Slope	R, S	——
Study Area OCS	J, K, L, M, N, O, P, Q E, F, G, H, I	A, B, C, D, E, F, G, H, I

[a] See Figures 1 and 2 for block and stratum definition.

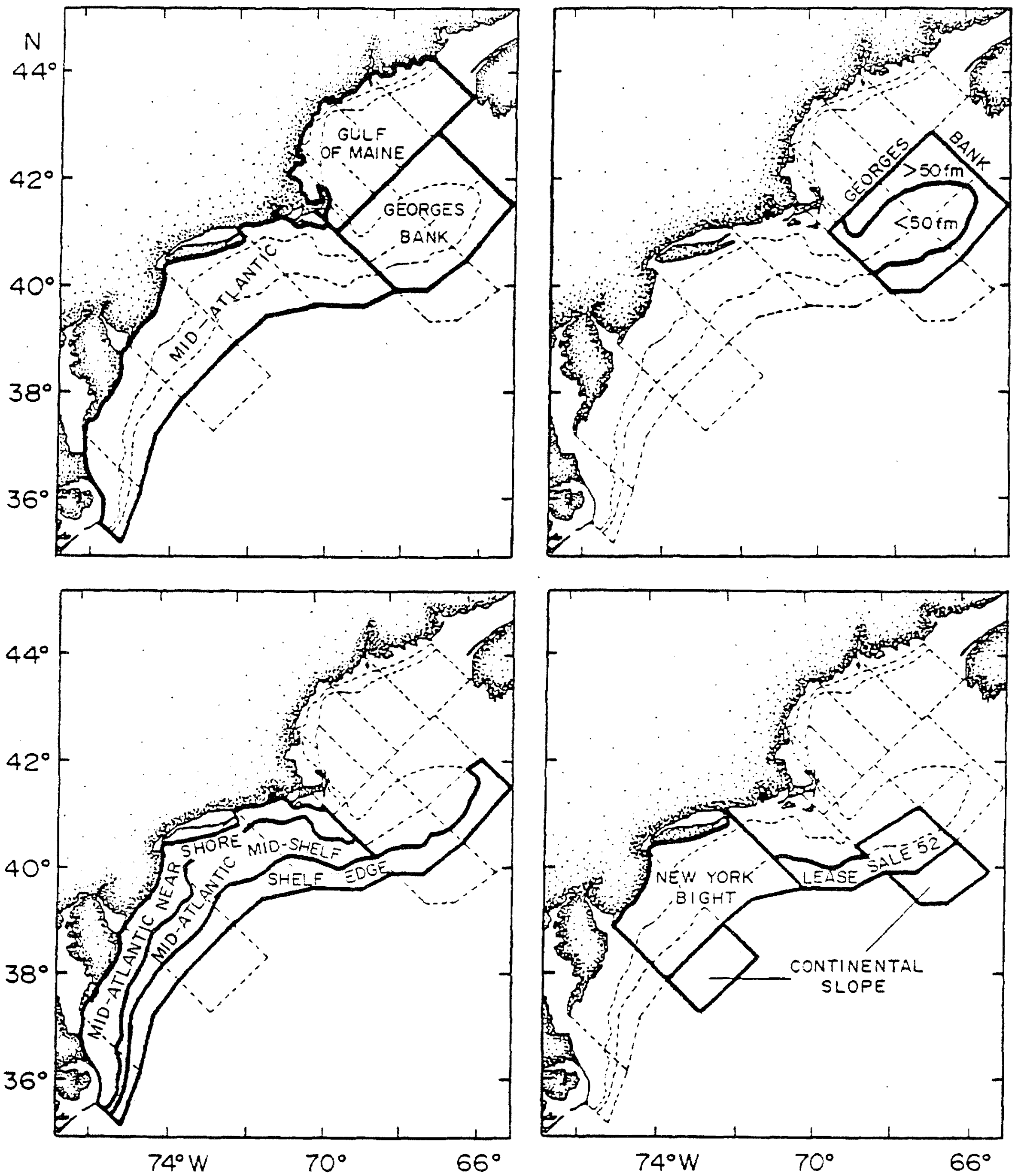

Figure 5. Regions defined within the CETAP study area and used to calculate average seasonal cetacean and turtle population densities and abundances. Dashed lines show the boundaries of the original aerial survey blocks and strata which were subsequently combined into these regions.

by region and season, which are included with the species accounts. In cases where post-stratification caused the maximum point abundance estimate to change significantly from the value without stratification of the 1979 data, both are included in the species accounts. For each species, the estimates which appear in the population estimate tables incorporate the post-stratification of the 1979 survey data.

Analysis of Cetacean Respiration and Dive Time Behavior

The primary mission of the two dedicated cruises (May 1980, May 1981) was to gather respiration and dive time data on endangered cetaceans in the Cape Cod area. The methodology for the analysis of these data are given in detail in the 1980 CETAP Annual Report and in Special Topic D (this volume).

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CHAPTER III

RESULTS & DISCUSSION

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SIGHTING EFFORT

1981 Sighting Effort

In the 13 month period from 1 January 1981 through 28 January 1982, 328 hours of on-watch observations were conducted by CETAP personnel over 33,737 n.mi. of trackline in and directly adjacent to the study area. In keeping with past practice, these sighting effort figures consider only trackline searched in sea states of Beaufort 3 or less. Since the shipboard platforms-of-opportunity program was discontinued at the end of 1980, the sighting effort in 1981 came from the four seasonal dedicated aerial surveys; endangered species flights in spring, summer, and fall; and platforms-of-opportunity flights aboard Coast Guard aircraft from February through October. The cumulative tracklines plotted by season are shown in Figure 6. The corresponding data are shown in Table 2.

Since the intent of the 1981 sampling program was not to continue with the general surveys of the study area, but rather to concentrate on present and proposed lease sale areas and site-specific sampling of areas containing concentrations of endangered species, the 1981 sighting effort was primarily in four areas south and east of Cape Cod, and two areas east and southeast of New Jersey.

The following summarizes the 1981 sighting effort:

1. The 1981 sighting effort was substantially less than in either of the two previous years. The on-watch hours were 4% of the total for all years, and the on-watch miles were 15% of the total (the discrepancy between the hours and miles figure is due to the exclusive use of aerial platforms in 1981).

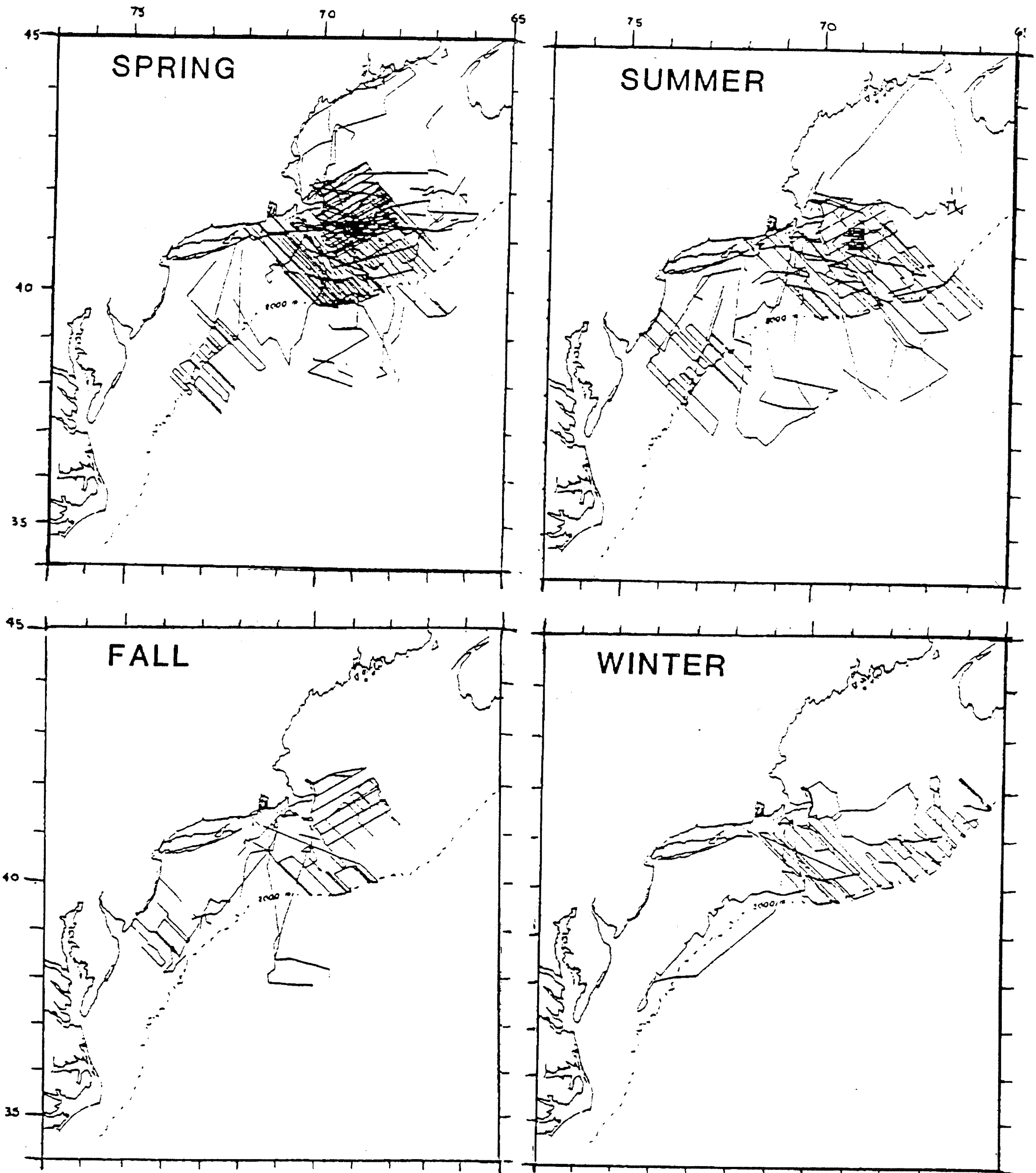

Figure 6. On watch tracklines flown by dedicated aircraft and aircraft-of-opportunity in sea states of Beaufort 3 or less during the 1981 field studies.

Table 2 Events recorded, track miles surveyed, hours on watch, and cetacean and turtle sightings made during the 1981 CETAP field studies. These sighting effort data consider only on-watch periods in sea states of Beaufort 3 or less.

Season/ Date	Dedicated Aerial					Aircraft-Of-Opportunity				
	Events	Miles	Hours	Cetacean Sightings	Turtle Sightings	Events	Miles	Hours	Cetacean Sightings	
Spring 20 Mar-20 Jun	2302	11399	123	654	39	564	4511	40	76	6
Summer 21 Jun-21 Sep	1571	5429	55	241	223	555	4004	32	67	22
Fall 22 Sep-20 Dec	476	2728	26	92	2	184	1298	11	17	12
Winter 21 Dec-19 Mar	498	2888	29	93	--	223	1480	12	20	1
Totals	4847	22444	233	1080	264	1526	11293	95	180	41

2. Due to the endangered species flights in spring and to the unusually foul weather in fall and winter (which prevented successful surveys), the seasonal variation in sighting effort was more extreme than in previous years. Spring had 47% of the total trackline miles for the year, summer 28%, fall 12%, and winter 13%.

3. Two areas were surveyed for the first time in 1981. The areas were located over the continental slope and defined by 50 mile extensions seaward of the 2000 m depth contour (Figure 5). The northern area, Block R, was sampled only once, on 1 August 1981. The Mid-Atlantic area, Block S, was sampled twice, on 8 June 1981 and 28 July 1981.

4. The best coverage of the study area in 1981 was in spring, in the areas south and east of Cape Cod. This was consistent with other years.

Summary and Evaluation of Total Sighting Effort

The entire CETAP field study took place during a 39 month period from 1 November 1978 through 28 January 1982. During this time, CETAP personnel surveyed 229,112 n.mi of trackline during 9,190 hours of on-watch observation in sea states of Beaufort 3 or less. This effort took place from dedicated aircraft, dedicated boats, ships-of-opportunity, and aircraft-of-opportunity. The data for 1979 and 1980 have been presented in the 1979 and 1980 CETAP Annual Reports. The data for 1981 are given in the preceding section. The cumulative data, summed over all years, are given in Tables 2 and 3. The graphic presentation of the cumulative sighting effort, in total and by season, is given in Figures 8a through 8d.

The following conclusions summarize the cumulative sighting effort results:

1. Sighting effort varied geographically and temporally (within years, between years, and between seasons)

2. Of the total on-watch miles surveyed, 51% were in 1979, 34% were in 1980, and 15% were in 1981.

3. The level of coverage varied with season. Using miles-on-watch as a measure, spring received 39% of the total coverage, summer 31%, fall 17%, and winter 12%. In general, the level of sighting effort was three times higher in spring than in winter.

4. Sighting effort likewise varied with location. Using the data in Figures 7 through 8d, in general, the area to the east and southeast of Cape Cod received the most coverage, and the areas over eastern Georges Bank and through the central Gulf of Maine received the least.

5. To translate the above yearly and seasonal figures to an overall measure of study area coverage, the number of events were tallied for each 10' quadrat in the study area and converted to a mileage figure using the CETAP 3 year average of 1 event = 5.4 n.mi. Assuming the area searched extends one mile to either side of the trackline, an average of 47% of the study area was surveyed during each of the 3 spring seasons, 37% during summer, 20% during fall, and 14% during winter. If one more conservatively assumes that the area effectively

searched is less than a 2 mile swath, a view consistent with findings reported by Hay (1982), Powers et al. (1982), and Scott and Gilbert (1982), then the percentage coverage is proportionately reduced. This may decrease the effective coverage by 1/2 for large whales and 3/4 for dolphins.

Table 3a Sighting effort summarized by platform type. Values shown are events recorded, track miles surveyed, hours on watch, and cetacean and turtle sightings made during all CETAP field studies - a 39 month period from 1 November 1978 through 28 January 1982. These sighting effort data consider only on-watch periods in sea states of Beaufort 3 or less.

Season/ Date	Dedicated Aerial					Ships-Of-Opportunity					Aircraft-Of-Opportunity				
	Events	Miles	Hours	Cetacean Sightings	Turtle Sightings	Events	Miles	Hours	Cetacean Sightings	Turtle Sightings	Events	Miles	Hours	Cetacean Sightings	Turtle Sightings
Spring 20 Mar-20 Jun	8773	48240	525	2146	279	4434	18257	2508	1109	21	2668	23860	207	385	201
Summer 21 Jun-21 Sep	7270	30078	308	1089	1322	5094	20872	2759	1150	77	2592	20663	179	350	527
Fall 22 Sep-20 Dec	2917	17310	177	501	235	3028	11760	1580	699	26	1045	11012	94	117	89
Winter 21 Dec-19 Mar	2448	18619	184	312	3	1429	4862	633	313	--	451	3579	36	100	7
Totals	21408	114247	1194	4048	1839	13985	55751	7480	3271	124	6756	59114	516	952	824

Table 3b Sighting effort summarized by season and for complete CETAP field studies. All platform types considered collectively. Values shown are events recorded, track miles surveyed, hours on watch, and cetacean and turtle sightings made during all CETAP field studies - a 39 month period from 1 November 1978 through 28 January 1982. These sighting effort data consider only on-watch periods in sea states of Beaufort 3 or less.

Season/ Date	Events	Miles	Hours	Cetacean Sightings	Turtle Sightings
Spring 20 Mar- 20 Jun	15875	90357	3240	3640	501
Summer 21 Jun- 21 Sep	14956	71613	3246	2589	1926
Fall 22 Sep- 20 Dec	6990	40082	1851	1317	350
Winter 20 Dec- 19 Mar	4328	27060	853	725	10
Grand Totals	42149	229112	9190	8271	2787

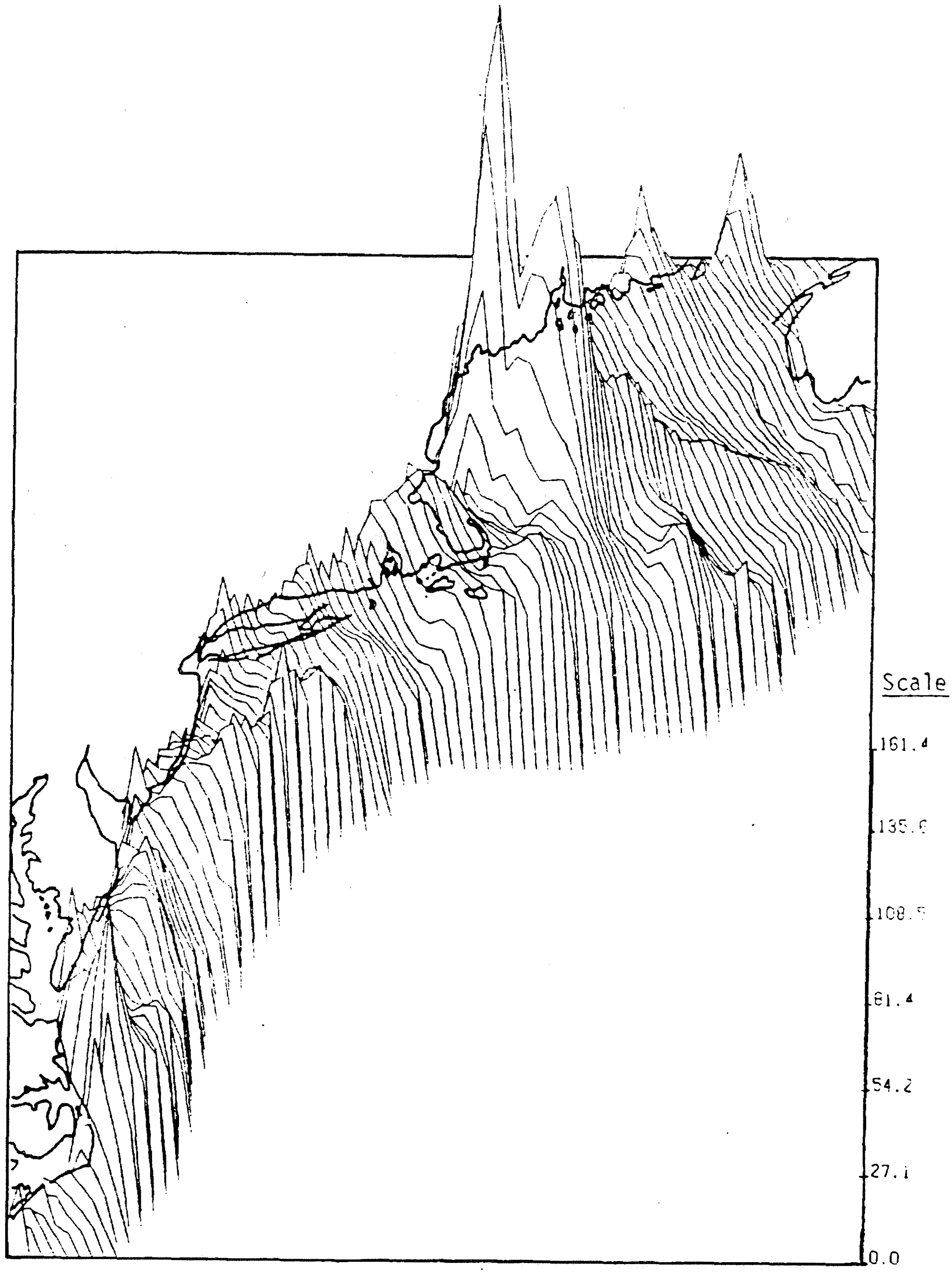

Figure 7. Total sighting effort for the 39 month CETAP field studies. Values plotted are the total number of events (a measure of sighting effort--see text for explanation) for each 10' quadrat within the study area after application of a binomial smoothing function. The data used are for on-watch periods in sea states of Beaufort 3 or less, and include both aircraft and surface vessel survey platforms.

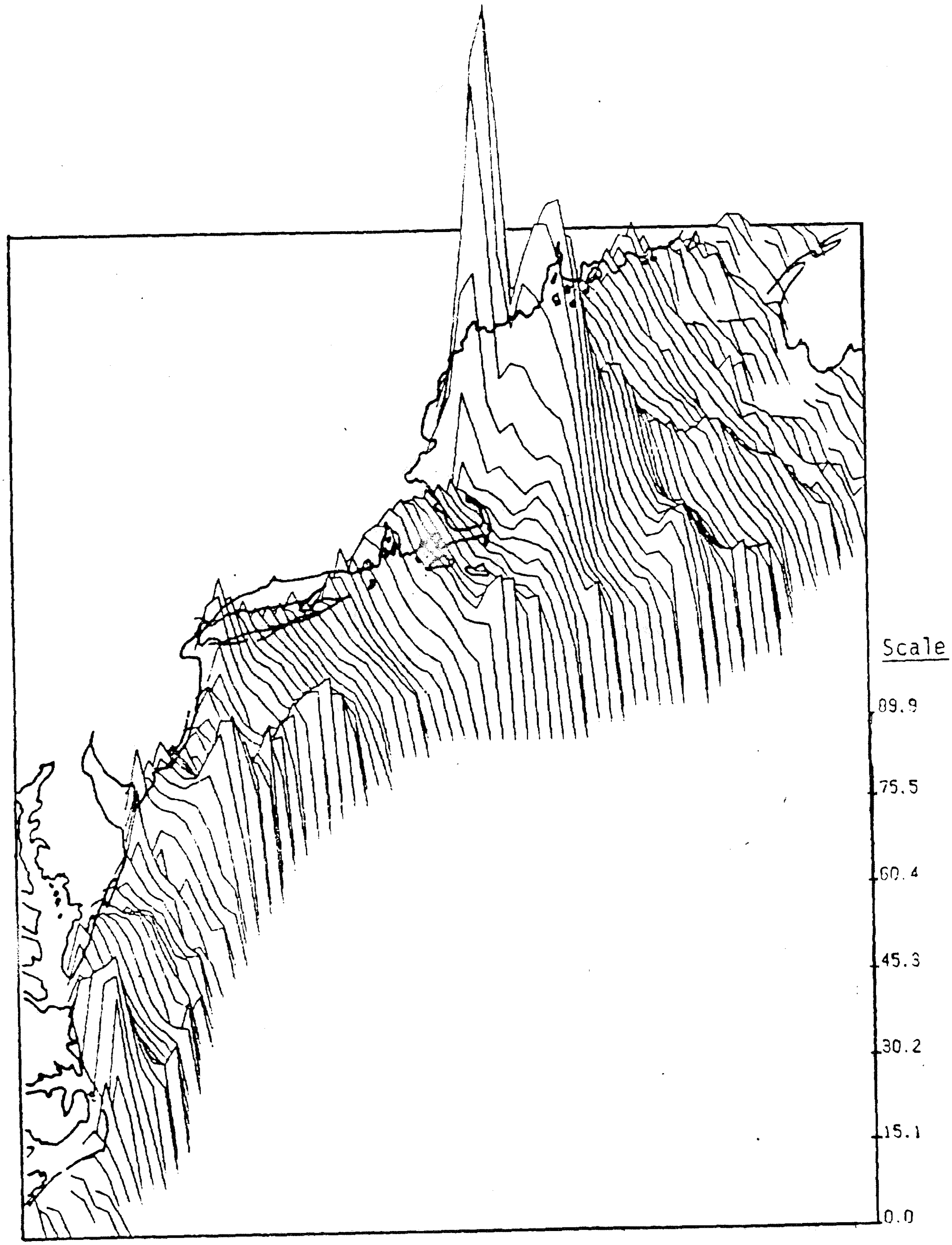

Figure 8a. Spring season sighting effort for the CETAP field studies. Note that the four seasonal effort plots have uniform scales for ease of comparison.

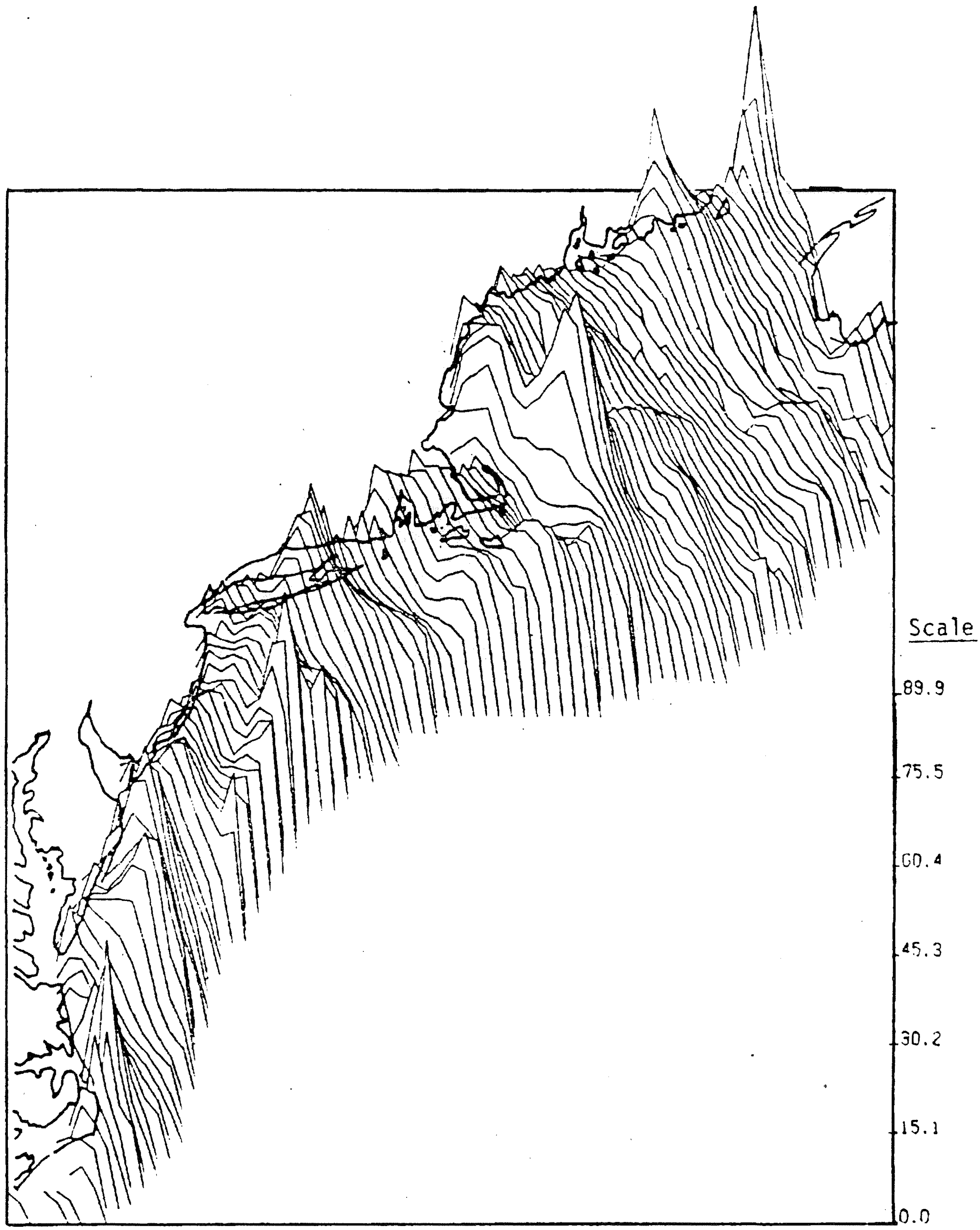

Figure 8b. Summer season sighting effort for the CETAP field studies. Note that the four seasonal effort plots have uniform scales for ease of comparison.

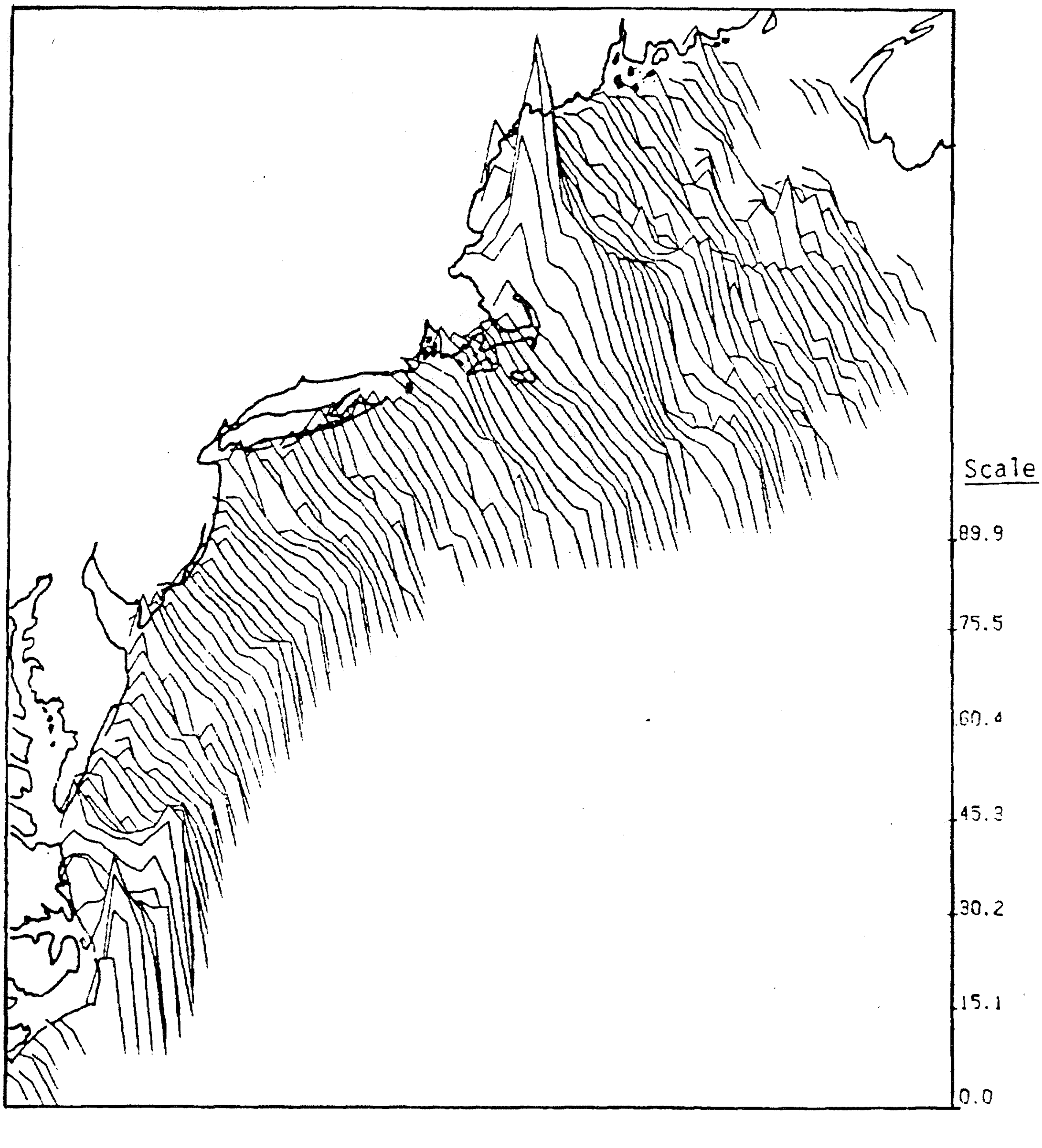

Figure 8c. Fall season sighting effort for the CETAP field studies. Note that the four seasonal effort plots have uniform scales for ease of comparison.

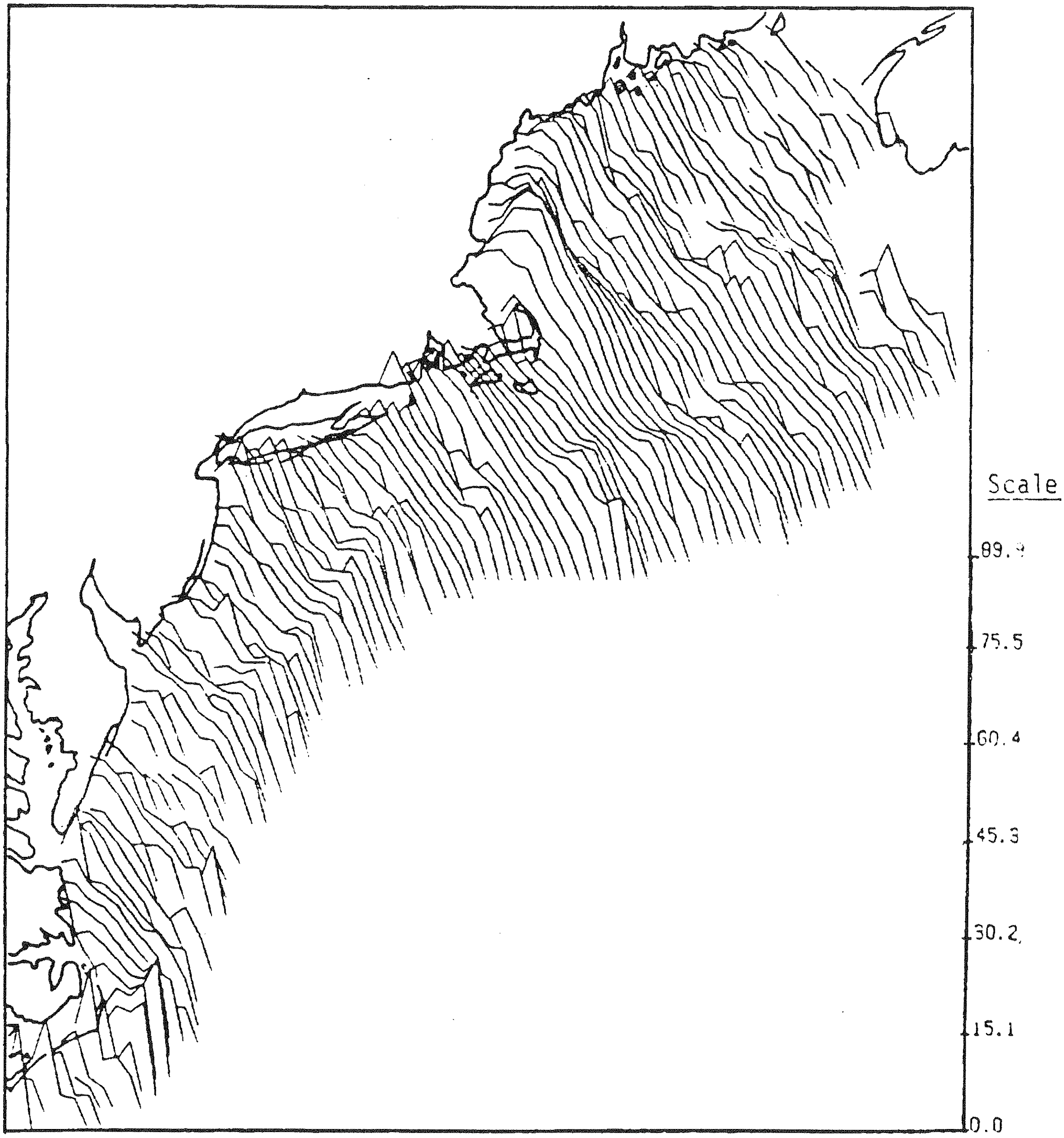

Figure 8d. Winter season sighting effort for the CETAP field studies. Note that the four seasonal effort plots have uniform scales for ease of comparison.

Survey Effort Relative to Population Estimation

The data on sampling effort during the 1981 main aerial surveys are presented in Table 4, listing platform, date, block, stratum, and number of transect lines completed for each sample. A total of 564 sightings were collected during these surveys under conditions qualifying them for use in population estimation. Of these, 84 were of large whales (*Balaenoptera physalus*, *B. borealis*, *B. acutorostrata*, *Megaptera novaeangliae*, *Eubalaena glacialis*, and *Physeter catodon*), 338 were of small whales (all remaining cetaceans observed), and 142 were of sea turtles.

The data on sampling effort during the 1981 endangered species surveys are presented in Table 5. A total of 132 sightings useable for population estimation were recorded, with 76 large whale and 56 small whale sightings. The combined data for 1981 are then: 160 large whale sightings, 394 small whale sightings, and 142 sea turtle sightings, for a grand total of 696.

Details of sampling effort for the 1979 and 1980 surveys, both main and special, can be found in the CETAP reports for those years. The three-year total data on sightings useable for population estimation are as follows:

> Main surveys: 312 large whale sightings, 1335 small whale, and 1168 sea turtle; total = 2815.
> Special surveys: 159 large whale (as defined above plus *B. musculus*) sightings, 212 small whale, and 4 sea turtle; total = 375.
> Combined: 471 large whale sightings, 1547 small whale, and 1172 sea turtle; total = 3190.

Table 4. Sampling effort during the 1981 main aerial surveys.

SURVEY	BLOCK	STRATUM	PLATFORM	LINES	DATE
A1	E	X	AT-11	5	4/25/81
A1	E	X	AT-11	2	5/18/81
A1	E	X	AT-11	5	5/19/81
A1	E	X	AT-11	5	5/21/81
A1	E	Y	AT-11	6	4/25/81
A1	E	Y	AT-11	5	5/14/81
A1	E	Y	AT-11	5	5/18/81
A1	E	Z	AT-11	8	5/11/81
A1	E	Z	AT-11	10	5/19/81
A1	E	Z	AT-11	9	6/ 1/81
A1	G	Y	AT-11	1	6/12/81
A1	G	Z	AT-11	16	6/12/81
A1	P	Y	AT-11	8	4/27/81
A1	P	Y	AT-11	7	4/28/81
A1	P	Y	AT-11	8	5/ 8/81
A1	P	Z	AT-11	5	4/27/81
A1	P	Z	AT-11	5	4/28/81
A1	P	Z	AT-11	5	5/ 8/81
A1	Q	Y	AT-11	9	5/10/81
A1	Q	Y	AT-11	9	6/ 2/81
A1	Q	Z	AT-11	5	5/10/81
A1	S	Z	AT-11	8	6/ 8/81
A2	E	X	AT-11	6	7/18/81
A2	E	Y	AT-11	4	7/25/81
A2	E	Z	AT-11	9	8/ 2/81
A2	G	X	AT-11	4	7/31/81
A2	G	Y	AT-11	7	7/31/81
A2	G	Z	AT-11	14	7/19/81
A2	P	Y	AT-11	8	7/26/81
A2	P	Z	AT-11	5	7/26/81
A2	Q	Y	AT-11	8	8/14/81
A2	Q	Z	AT-11	4	8/14/81
A2	R	Z	AT-11	6	8/ 1/81
A2	S	Z	AT-11	6	7/28/81
A3	E	X	AT-11	4	11/ 2/81
A3	E	Y	AT-11	5	11/ 2/81
A3	E	Z	AT-11	10	12/ 1/81
A3	G	X	AT-11	4	12/13/81
A3	G	Y	AT-11	7	12/13/81
A3	P	Z	AT-11	5	12/ 4/81
A4	E	X	AT-11	5	1/19/82
A4	E	Y	AT-11	4	1/19/82

Table 5. Sampling effort during the 1981 endangered species surveys.

SURVEY	BLOCK	STRATUM	PLATFORM	LINES	DATE
E1	1		Skymaster	5	5/ 8/81
E1	1		Skymaster	5	5/14/81
E1	1		Skymaster	5	5/18/81
E1	1		Skymaster	3	7/ 9/81
E1	1		Skymaster	3	9/26/81
E1	1		Skymaster	3	10/14/81
E1	2		Skymaster	5	5/ 9/81
E1	2		Skymaster	5	5/10/81
E1	2		Skymaster	5	5/19/81
E1	2		Skymaster	3	7/ 9/81
E1	2		Skymaster	3	9/26/81
E1	2		Skymaster	3	10/14/81
R1	2		AT-11	8	5/21/81
R1	2		AT-11	9	6/ 2/81
R2	2		Skymaster	6	7/25/81
R2	2		Skymaster	8	5/14/81

POPULATION ESTIMATION: Estimates of f(0)

The first consideration in calculating population estimates is to estimate the value of f(0). This parameter is the probability density function of perpendicular distances from the transect line, evaluated at a distance of 0. The reciprocal of f(0) is the effective half-swath, the width of the strip on either side of the transect which is effectively sampled. Dividing the average number of individuals sighted per km of transect by the effective transect width yields a measure of species density (individuals/km^2). This is the basis of the line transect population estimation technique (Burnham et al., 1980).

Estimates of f(0) for the various taxonomic categories observed, calculated from the entire three-year sighting record, are presented in Table 6, along with the estimation model used and the calculated effective half-swath. These estimates were obtained using the 'PROGRAM TRANSECT' analysis program developed by the Utah Cooperative Wildlife Research Unit (Laake et al., 1980) and based upon line transect methods presented in Burnham et al. (1980). The estimator model providing the best fit to the observed distribution of right angle distances for each category was the model selected. Because sighting conditions differ between the two survey platforms, separate estimates were calculated for each wherever possible. Species and categories where the total number of sightings was less than 30 were pooled into the general categories 'large whale', 'small whale', and 'turtle', as were groups where the pooled data provided a better fit to the model.

Table 6. Estimates of f(0) for the taxonomic groups listed.

Group	Platform	Model	f(0)	Effective Half-swath (km)
Large whales	AT-11	FSER	1.0253	0.9753
Large whales	Skymaster	FSER	0.8044	1.2432
Balaenoptera acutorostrata	Both	NEXP	3.26	0.3065
B. borealis	AT-11	EXPS	2.529	0.3954
B. physalus	AT-11	NEXP	1.598	0.6258
B. physalus	Skymaster	FSER	0.7242	1.3808
Eubalaena glacialis	AT-11	NEXP	1.681	0.5949
E. glacialis	Skymaster	EXPS	0.9318	1.0732
Megaptera novaeangliae	AT-11	HNOR	0.9595	1.0422
M. novaeangliae	Skymaster	NEXP	0.7573	1.3205
Physeter catodon	AT-11	FSER	0.9723	1.0285
Small whales	AT-11	HNOR	3.503	0.2855
Small whales	Skymaster	NEXP	1.922	0.5203
Delphinus delphis	AT-11	FSER	2.015	0.4963
Grampus griseus	AT-11	FSER	1.555	0.6431
Globicephala spp.	Both	FSER	1.673	0.5977
Lagenorhynchus spp.	AT-11	NEXP	2.848	0.3511
Lagenorhynchus spp.	Skymaster	NEXP	1.744	0.5734
Phocoena phocoena	Skymaster	NEXP	3.616	0.2766
Stenella spp.	AT-11	HNOR	1.141	0.8764
Tursiops truncatus	AT-11	FSER	1.446	0.6916
Turtles	Both	FSER	2.867	0.3488

*

Models are: FSER - Fourier Series, NEXP - Negative Exponential, EXPS - Exponential Power Series, HNOR - Half-Normal.

SPECIES ACCOUNTS

Preface

The following section contains the species accounts for the 26 species of cetaceans and 4 species of turtles sighted during the CETAP field studies.

Within each species account the results are arranged under major headings and subheadings relating directly to MMS/CETAP program objectives and goals. These headings are descriptive of the information contained within.

When examining these materials, the reader should be aware of the following:

1. Different analyses used different data sets. Some analyses used the entire data set, while others used subsets of the data. This information is given in the text, and typically the tables and figures will include the number of observations used. For example:

    Plots of sighting distribution -- all sightings of the given species in the CETAP database are used (except historical, unless otherwise noted).

    3-D plots of relative abundance -- uses a sighting of the given species collected aboard dedicated aircraft, and ships and aircraft-of-opportunity during on watch periods in sea states of Beaufort 3 or less. This method employs a subset of the complete database and is typically about 75% of the total sightings.

Tables and figures giving population estimates -- employs the most restricted data set, using only sightings made on rigorously defined census tracklines. This data treatment typically uses about 20% of the total sightings.

Since the same analysis for different species used the identical data set the results reported within a topic are comparable between species. However, the results reported within a given species account may not be directly comparable between topics, as each topic uses a unique data set, as described above.

2. The practice in this Final Report is to consider all data either as a total or subdivided by season. The total data include all observations. Seasons are defined according to astronomical or calendar convention. This means that:

Spring	-	March 20 through June 20
Summer	-	June 21 through September 21
Fall	-	September 22 through December 20
Winter	-	December 21 through March 19

3. As an aid to interpretation of species occurrences relative to BLM Lease Sale Areas, Proposed Lease Sale Areas, and bathymetry, transparent overlays of present and Proposed Lease Sale boundaries and selected depth contours (isobaths) are included in a pocket attached to the inside back cover of this report.

Eubalaena glacialis - Right whale - Endangered Species

INTRODUCTION

1981 Data. The 1981 data on the right whale were consistent with that from other years. Of particular interest is the migration information obtained through work on individual identification and resighting, a project which has been advanced by analysis of the cumulative three year data base. These results, along with a summary of all findings, are presented below.

Number of Sightings. *E. glacialis* was the fourth most commonly sighted large whale in the study area. The 380 sightings of 988 individuals accounted for 9% of the baleen whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 2.6, with a mode of 1, and a range from 1 to 46. This small group size was typical of all baleen whales and, for the most part, large whales.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The sighting distribution of the right whale is shown in Figures 9a through 9d. During winter, right whale sightings were very sparse. Right whales were observed off Cape Hatteras, NC, with scattered sightings south of Long Island and Nantucket. It is not known if these are wintering areas or areas which right whales pass through on their migration. The majority of right whale sightings were seen in the spring when aggregations were observed in the Great South Channel area. Scattered sightings were also made along the coast from North Carolina to Cape Cod, including southwestern Georges Bank. Additional sightings occurred throughout the northern Gulf of Maine, including Stellwagen Bank, off Cape Ann, and a single sighting on Browns Bank. Adjusted for effort, the major areas of concentration during the spring are the Great South Channel area, and the northern edge of Georges Bank. These spring time aggregations were seen in roughly the same area in 1980 and 1981, though the major area of concentration in 1979 was observed approximately 60 n.miles north of the Great South Channel area.

During the summer, the majority of sightings occurred in the Bay of Fundy and on Browns Bank. This is in accordance with observations made by Kraus and Prescott (1981,1982) and Sutcliffe and Brodie (1977). Additional scattered sightings occurred in the Great South Channel area and in the northern Gulf of Maine primarily along the coast from Massachusetts to Maine. Effort adjusted, the majority of the summer sightings occurred in the Bay of Fundy and on Browns Bank.

Scattered observations of right whales occurred in the fall, primarily off Cape Ann, with scattered sightings off Cape Cod, the northern edge of Georges Bank, and along the coast from New Jersey to North Carolina.

There were no sightings of right whales in Lease Sale Areas 40, 49, or 59.

Feeding. Sightings of surface feeding by right whales were noted in several areas, including the interior portions of Georges Bank, the southern portion of the Great South Channel, and scattered sites in the eastern half of the Gulf of Maine (Fig. 9e). These sites all coincided with areas of general sightings of right whales. Surface feeding sightings accounted for only 6% of total right whale sightings. Over 90% of feeding sightings were made in spring and summer, mostly in spring.

Right whales, like sei whales, have been described as "skimming" copepod feeders (Mitchell, 1974; Nemoto, 1970). However, recent studies (Watkins and Schevill, 1976, 1979; this report) indicate that most right whale feeding is done sub-surface, and hence, would not be subject to observation. This undoubtedly accounts for the low percentage of surface feeding observations in this study. Thus, we must consider the main general sighting pattern, at least north of Long Island, also as an indication of feeding areas. In that respect, it is apparent that the northern portion of the Great South Channel, Cape Cod Bay/Jeffreys Ledge area, and the southern edge of Georges Bank are also of importance to feeding right whales. It is also of considerable interest that there was relatively little overlap between right and sei whales, despite their similar feeding habits. In particular, right whales on Georges Bank were most commonly seen inside the 100 m contour, while sei whales were most often seen deeper than 100 m. Their one main area of overlap was the southern portion of the Great South Channel. Although both species are copepod feeders, perhaps they are dividing food resources in a more refined manner, e.g., different species of copepods. Or alternatively, right and sei whales may have different efficiencies relative to their feeding strategies and behaviors, and hence one species may outcompete the other, depending on differential prey abundances. Such a hypothesis has yet to be tested.

No right whale surface feeding sightings were made directly within the Lease Areas. However, a significant number of surface feeding sightings were made directly to the west of Areas 42 and 52. The Great South Channel concentration of feeding right whales is directly to the northwest of Area 42 and Proposed Area 52.

Breeding: No specific data on the actual breeding activities of right whales are available. On several occasions, groups of 3 to 9 individuals were observed as part of a larger aggregation consisting of up to 46 individuals. The individuals within the subgroups were often engaged in close-contact behavior. Often, one individual would lie belly up while the associated individuals would mill around and nudge this central individual, sometimes sliding their chins on its belly. When the central individual turned dorsal side up to breathe, rolling, belly-to-belly contact, and occasionally an erect penis were observed. Intromission was not observed in these situations. This type of behavior was observed in the Great South Channel area, in the Bay of Fundy, and on Browns Bank. Kraus and Prescott (1982) also describe this behavior in summer in the Bay of Fundy, where intromission was observed on one occasion. It is speculative whether this behavior is actually successful mating behavior or a behavior involved with organization of social group structure, or both.

Calves and Juveniles. During the three year survey period, 17 sightings of right whale calves or juveniles (4% of all right whale sightings) were reported; Figure 9f shows their distribution. These sightings were concentrated in shallow coastal waters within the Great South Channel and between Provincetown and Jeffreys Ledge. Two additional calf sightings were reported farther north near the Grand Manan Banks. Although many adult right whales were found between Cape Cod and Cape Hatteras, no calves were seen south of Nantucket. Most of the calf sightings (13) were made during the spring. Calves were seen only twice during the summer (the two northernmost sightings) and twice during the fall. No calves were found during winter months.

The relatively high number of calf sightings during the spring may have been: 1) an artifact of more intensive sighting effort from the Endangered Species Survey; 2) the result of recent births of calves in local waters; 3) the result of an influx of calves from other areas; or 4) a combination of these factors. Although a definite calving ground for right whales has not been discovered, calves may be born near Cape Cod during the winter (Watkins and Schevill, pers. comm., cited in Goodale, 1982). Winter reports of young calves close to shore between Florida and Cape Hatteras have led to the suggestion of a calving ground in southern waters (Winn et al., 1981). The absence of calf sightings between Cape Hatteras and Nantucket during the CETAP survey suggests that calves did not migrate from the hypothetical southern calving grounds to Cape Cod along the continental shelf. Two possible explanations were presented (CETAP 1980 Report): 1) calves migrated from southern to northern waters seaward of the continental shelf, outside of the CETAP survey area; 2) calves from the south did not migrate to the north, implying that there are at least two discrete right whale stocks. Alternatively, the absence of southern calf sightings may have been an artifact of limited sighting effort during winter months.

The two summer calf sightings near Grand Manan Banks tentatively suggest a northerly movement of calves after their first appearance near Cape Cod in the Spring. This is supported by reports of calves in the Bay of Fundy during the summer (Kraus and Prescott, 1982).

Most calves were seen among adult groups of 2-4 animals, although groups as large as 14 animals were found with calves. Two instances of apparent nursing were observed during the spring in the Great South Channel.

Right whale calves were not found within Lease Sale Areas 40, 42, 49, or 59, or within Proposed Lease Sale Area 52.

Areas. The major area of sightings for right whales is the funnel basin region which is defined as the area comprising the Great South Channel, bounded on the west by the edge of Nantucket Shoals, and on the east by the edge of Georges Bank. The area extends northward to a wider area from the northern tip of Cape Cod due east to Georges Bank. Large aggregations were seen in this area in spring and early summer. Browns Bank off Nova Scotia and the Bay of Fundy were major areas of concentration for right whales in the summer and early fall. A smaller concentration of right whales was seen on the northern edge of Georges Bank in the spring and fall. These major areas are illustrated in Figure 9b, which has been adjusted for effort. In general, right whales were observed close to shore in the area south of Cape Cod but this may represent only a small proportion of the population. The distribution then tends to spread along the coast north of Cape Cod, as well as along the northern edge of Georges Bank, to the northern summering areas.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 7a for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 9g. The peak average abundance estimate for right whales in the Study Area was 380 (+/- 688) and occurred in the spring. The maximum point abundance estimate for this species was 493 (+/- 1100) in sampling block P, stratum z during April 1981. These estimates are adjusted for diving behavior using the shipboard behavioral data collected in 1980 and 1981. The estimates may be positively biased if the proportion of time an average individual right whale was observed from shipboard is not representative of pods sampled from aircraft.

Conservatively, based on analysis of aerial photos, a minimum of 50 individuals can definitely be reidentified in the future on the basis of the callosity patterns. Aerial sightings were made of an additional 35 individuals, which may possibly be re-identified in the future. Combining these data, a minimum of 85 individuals have been identified through aerial observations.

Analysis of the shipboard photos has resulted tentatively in a minimum of 47 individuals which can definitely be re-identified on the basis of the callosity pattern, plus an additional 20 possibly reidentifiable individuals. Conservatively, a minimum of 67 individuals have been identified through shipboard observations (To date no shipboard sampling effort has been undertaken by CETAP in the Browns Bank region nor the Bay of Fundy). To date no adequate method of comparing shipboard photos with aerial photos has been established.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 134 sightings of this species. The average water temperature for right whale sightings was 9.4°C, the coolest found for all baleen species; the mode was 8.0 with a range from 4.0 to 18.0°C.

Depth (m). The average depth for right whale sightings was 140m, with a mode of 128, and a range from 5 to 2377m. This mean depth was the third deepest found for all baleen whales.

BEHAVIOR

Associations. *E.glacialis* was observed with one or more of 7 cetacean species in 14% of sightings. *M.novaeanagliae*, *B.physalus*, and *L.acutus* were the primary species involved. Associations among these species numbered 19, 18 and 15 occasions respectively and totaled 64% of all right whale associations. On an additional 19 occasions (24% of total) right whales were reported with an unidentified species of whale or dolphin. Only incidental occurrences with four other species were recorded (for details, refer to Table 30).

A frequent association, not reported for the CETAP study area, has been reported by Wursig and Wursig (1979) between *E.glacialis* and *T.truncatus* in the waters off Argentina. The description of the behavior of both species provided by the authors, e.g., rapid swimming back and forth before the whale and bowriding by the dolphins and surging, lunging and "snorting" by the whale, essentially duplicates that recorded by CETAP observers between E.glacialis and L.acutus, with calves of both species present, in the Great South Channel area. Wursig and Wursig concluded, in their instance, that the association appeared to be play, which suggests that not all associations are necessarily feeding oriented.

Migration and Movement. A model (scheme) of the annual activity cycle of right whales in the Western North Atlantic is presented in detail as Special Topic A in this report. Each model component may be treated as a hypothesis with varying levels of testing and confidence. The various phases of right whale annual activities may be summarized as follows: a wintering period off Georgia-Florida followed by a migration to the Great South Channel area where some individuals stop to feed for several months. These individuals then migrate in June-July to the Bay of Fundy and Browns Bank area where they stay until October. A long migration without extended stops then occurs from October to January to the Georgia-Florida area.

Based on bonnet pattern analysis, resightings of individual animals over 30 miles apart have been tentatively determined. Eight individuals have been resighted within a calendar year. Four animals moved from the Great South Channel area in the springtime to the Bay of Fundy in the summer, and two went to Browns Bank. No connection has been made between Browns Bank and the Bay of Fundy at this time. More comparisons must be made. One animal went southward for 50 miles before going to Browns Bank. Ten animals were resighted between calendar years again showing a movement between the Great South Channel and the Bay of Fundy plus Browns Bank. Also, connections between areas intermediate to the above places and the Great South

Channel are demonstrated. Details of these resightings are provided in Tables 7b and 7c; and are shown plotted in Figures 9h and 9i.

Respiration and Dive Times. A total of 37.7 hours of observations of the surface and diving behavior of 31 individual right whales were recorded from the R/V *Tioga* during May 1980 and May 1981. The duration of single surface behavioral acts ranged from 1 sec to 10.8 min, with a median value of 7.0 sec. Dives ranged in length from 1 sec to 15.8 min, with a median of 14.4 sec. The median length of surface activity bouts was 2.55 min. This value was significantly longer than the medians for both fin and humpback whales. The median inter-bout dive duration was 5.38 min, again significantly longer than the medians for both fin and humpback whales. Right whales spent a median of 34% of their total time budget engaged in surface activity bouts, which was significantly greater than the percentages for fin whales and humpback whales. The median respiration rate observed was 65/h, which was not significantly different from either the fin or humpback whale value. Similar sets of values were calculated and compared for various social categories of right whales, including solitary whales, whales in pairs or trios, calves, and cows accompanying calves. No significant differences among the social categories were found for surface activity bout duration, percentage of total time spent in surface activity, or respiration rate. For inter-bout dive duration, the median for solitary individuals (7.09 min) was significantly longer than the medians for calves, cows, and pair/trio members (1.88, 1.92, and 3.92 min, respectively). (See Special Topic D, this report).

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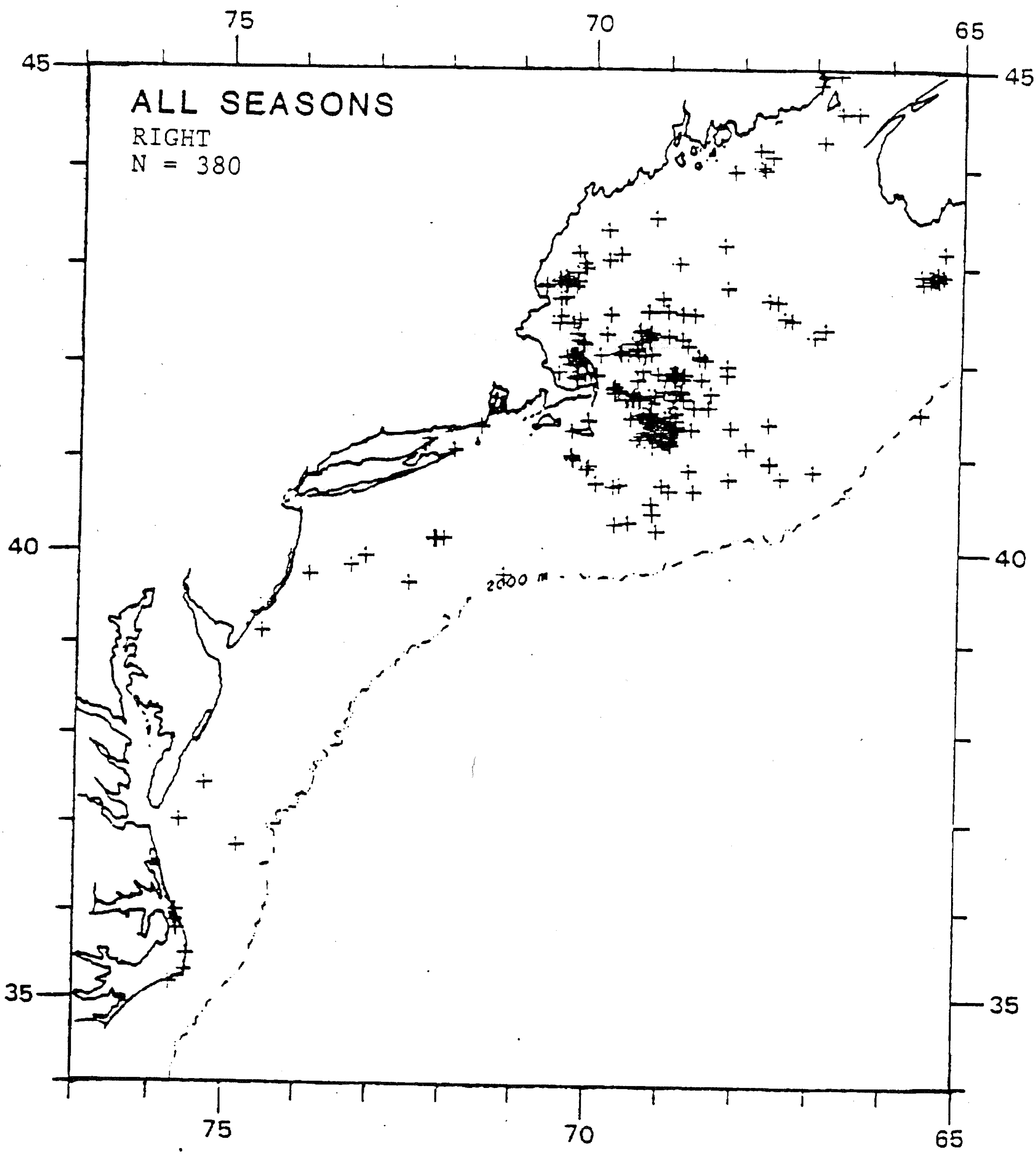

Figure 9a. All sightings of the right whale, <u>Eubalaena glacialis</u>, for the 39 month period -- 1 November 1978 through 28 January 1982.

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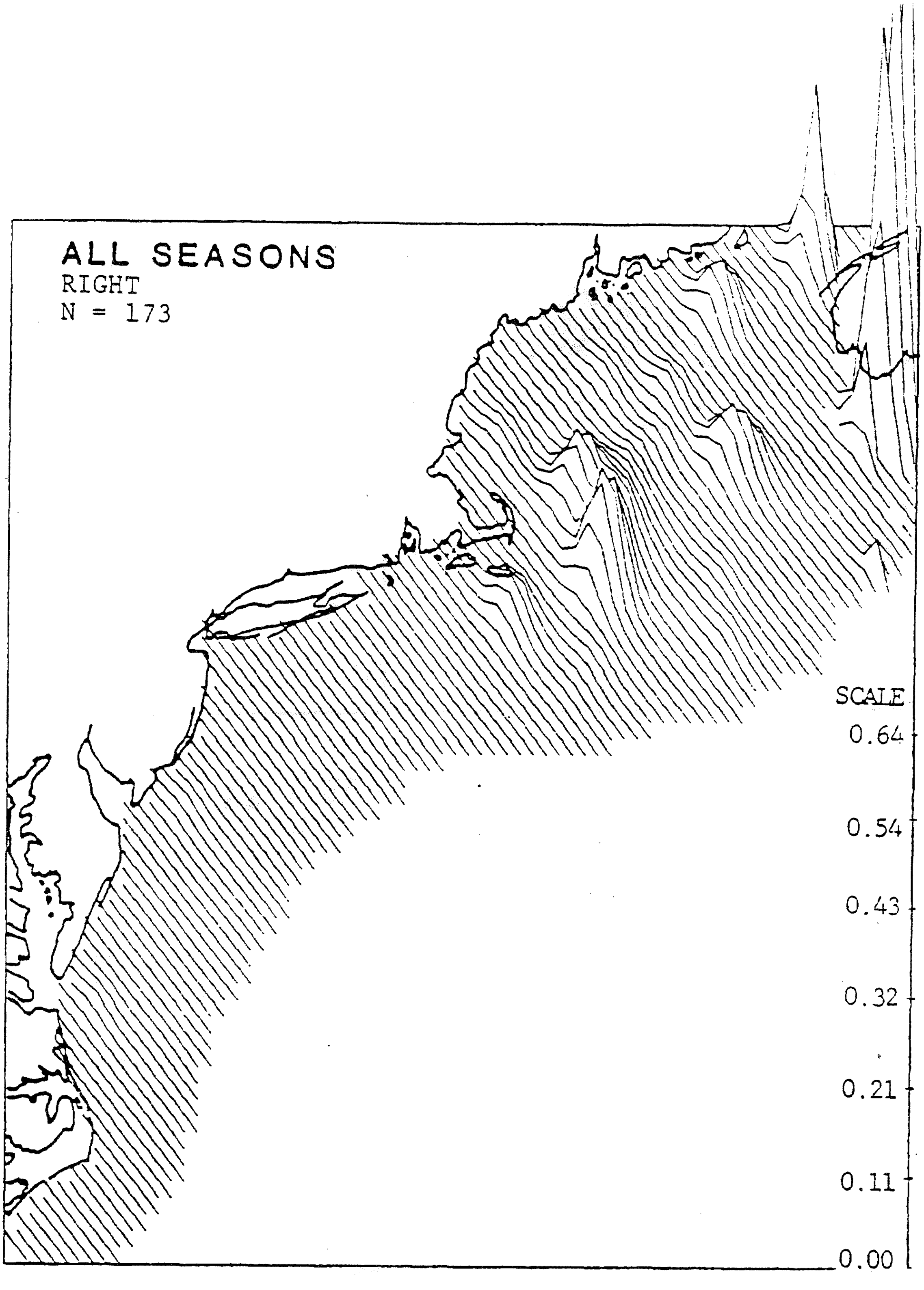

Figure 9b. The relative abundance of E. glacialis for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

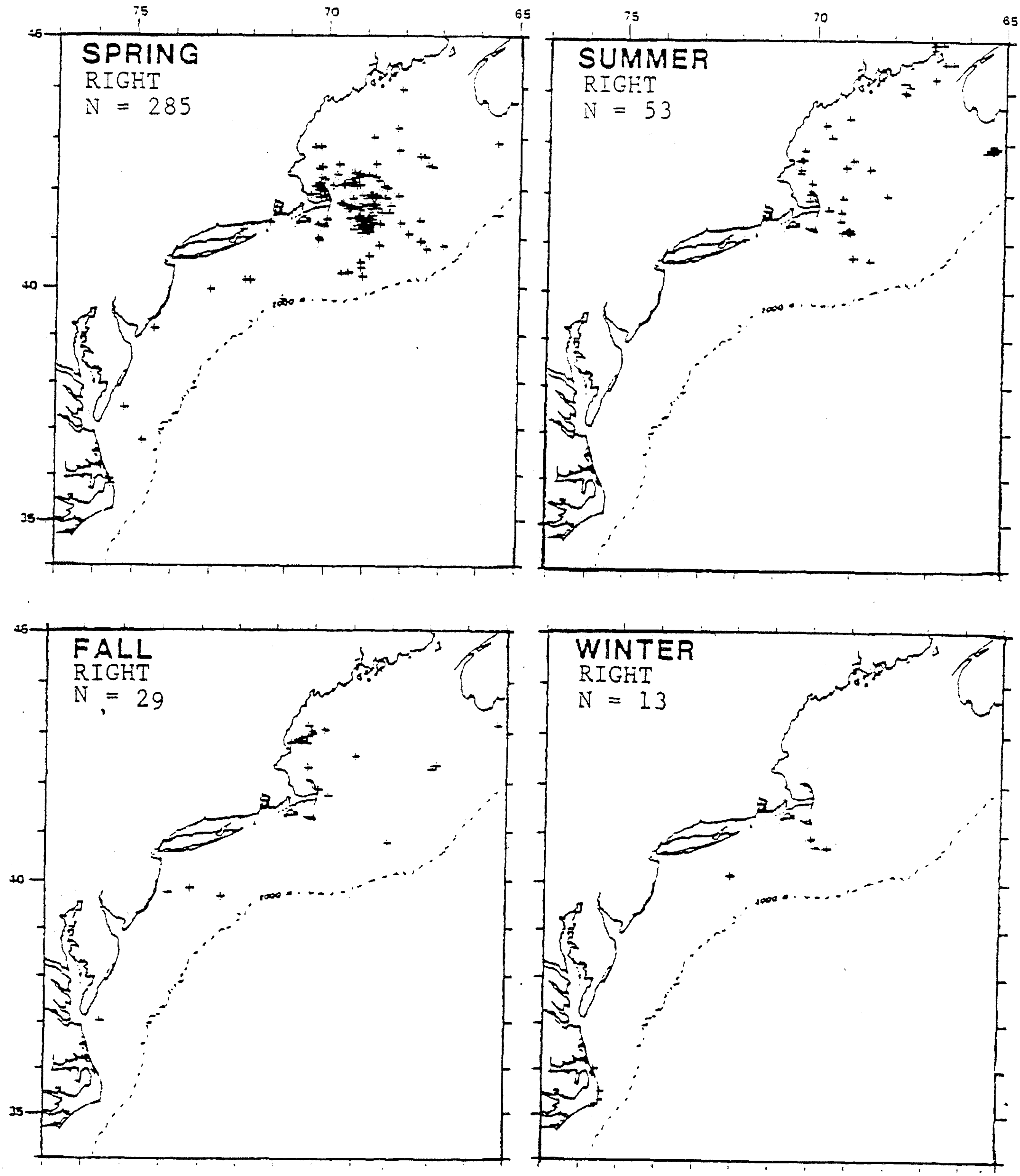

Figure 9c. The sighting distribution of *E. glacialis* by season.

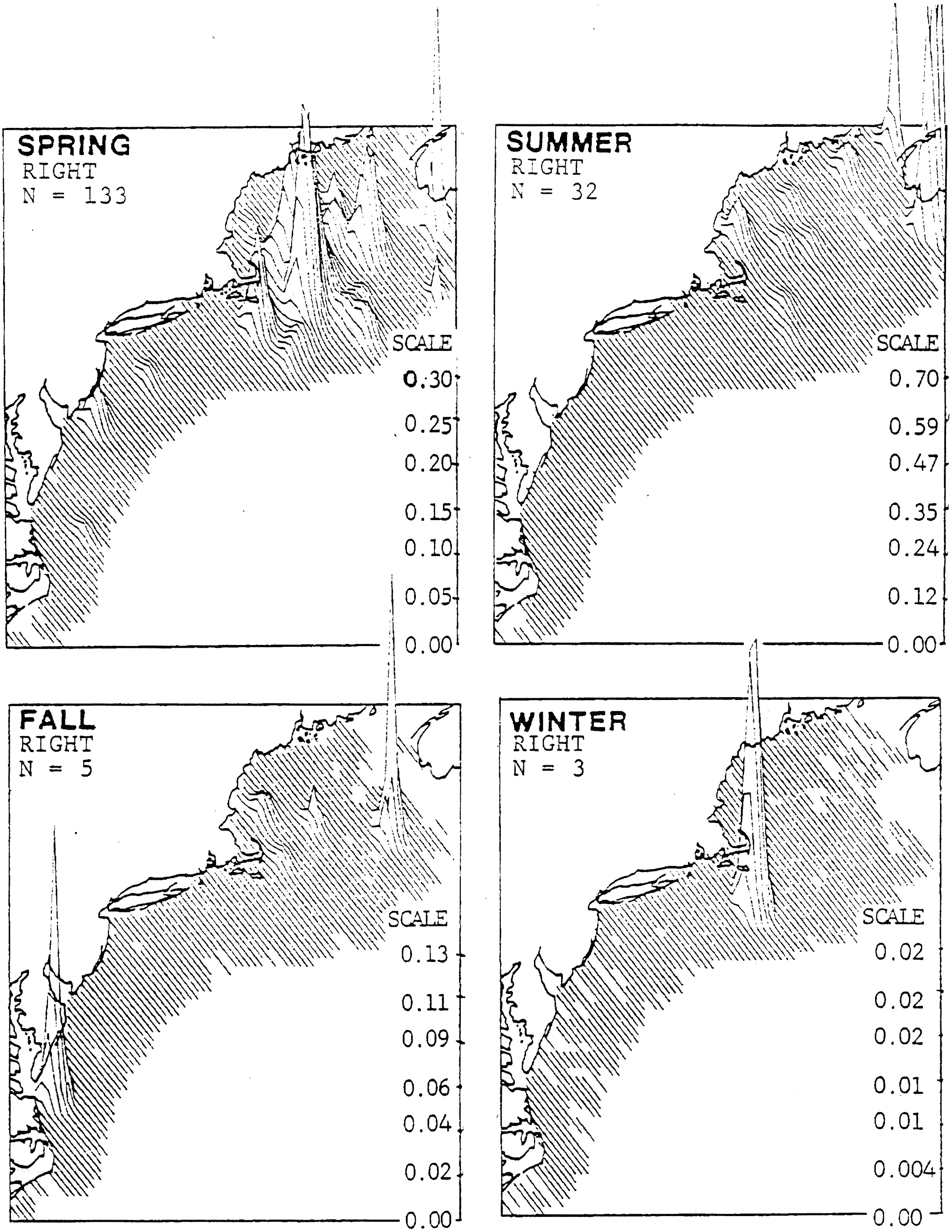

Figure 9d. The relative abundance of E. glacialis by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

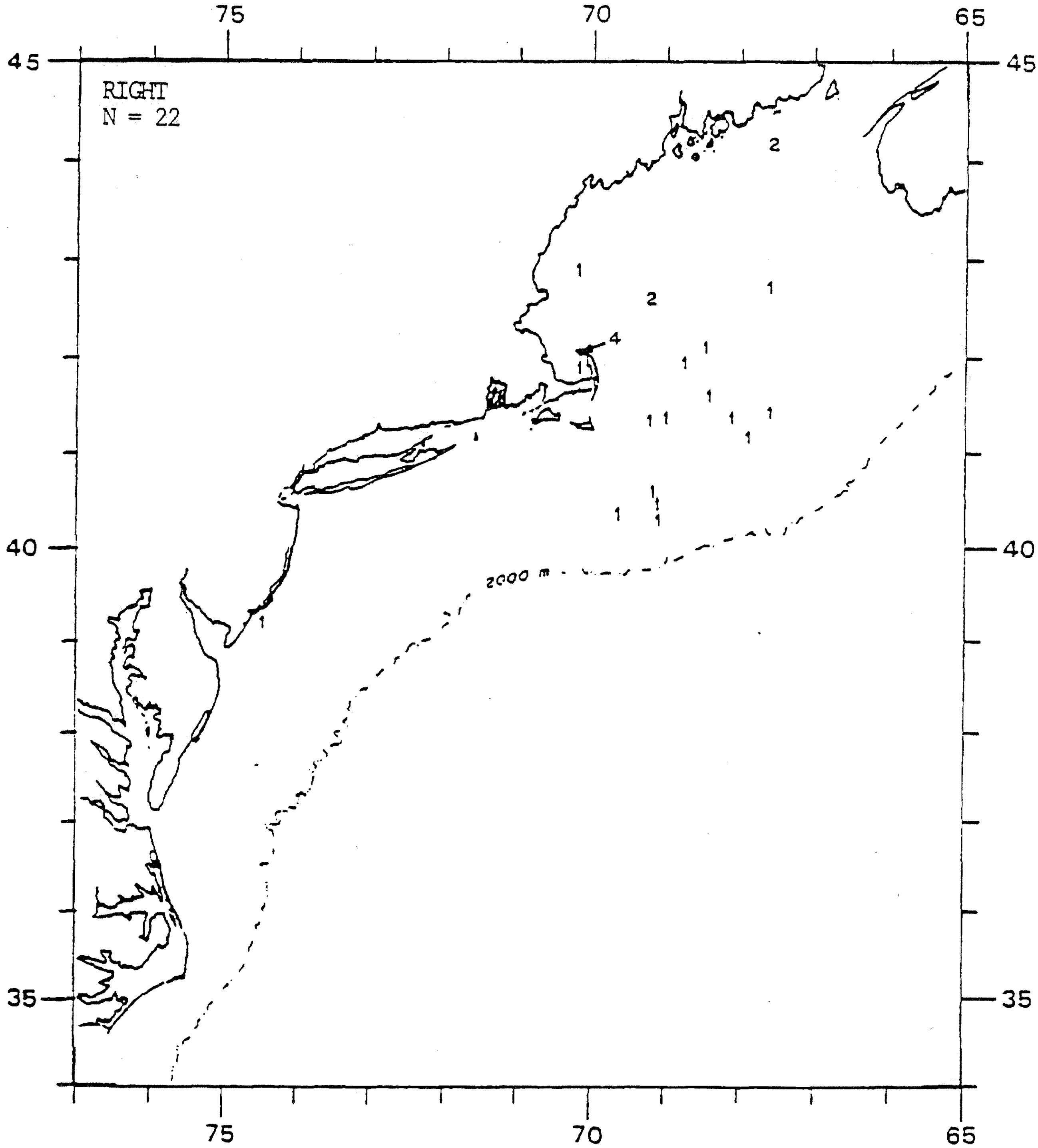

Figure 9e. Locations of sightings of feeding or apparent feeding of E. glacialis. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

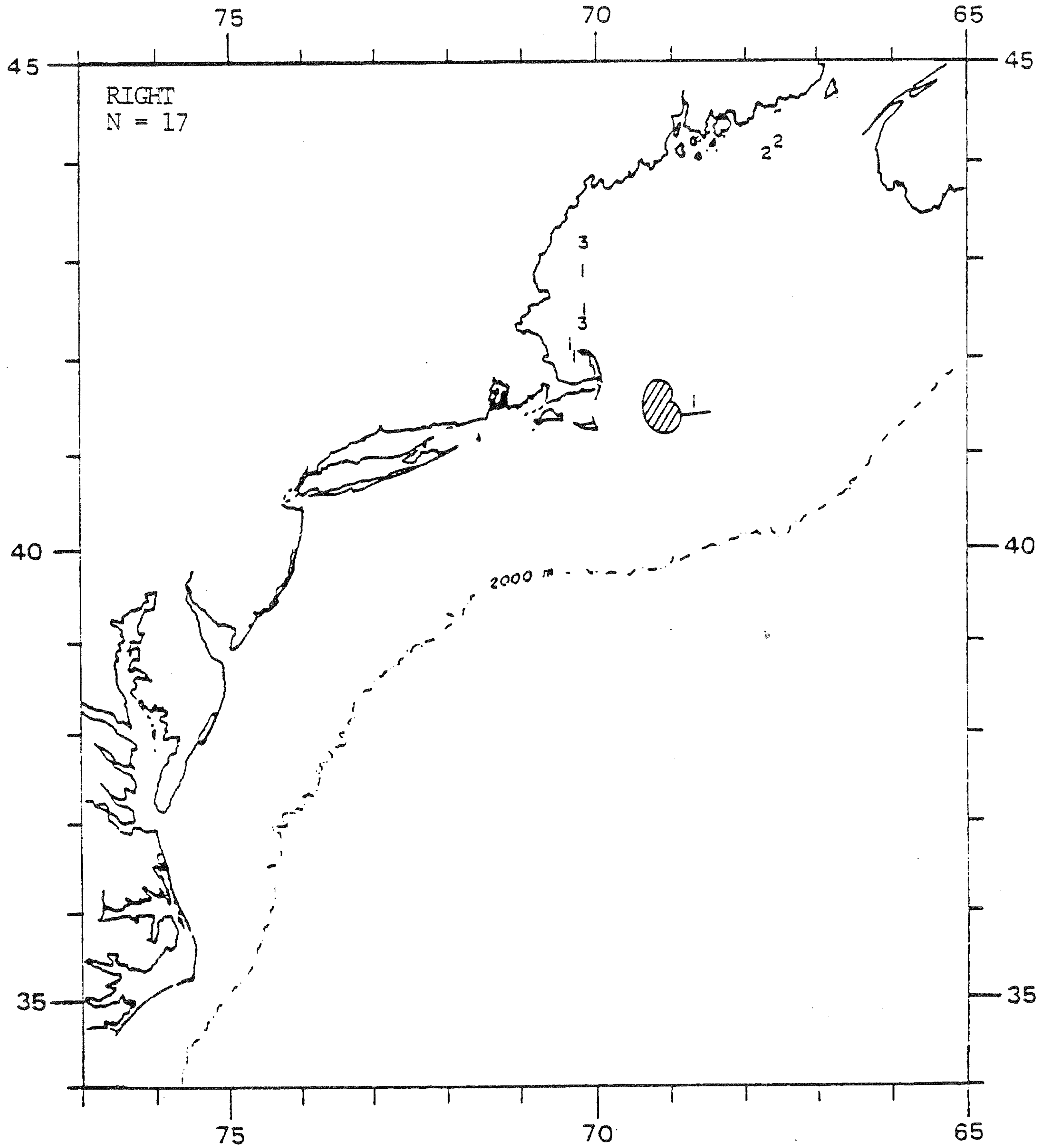

Figure 9f. Sightings of calves or juveniles of E. glacialis. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

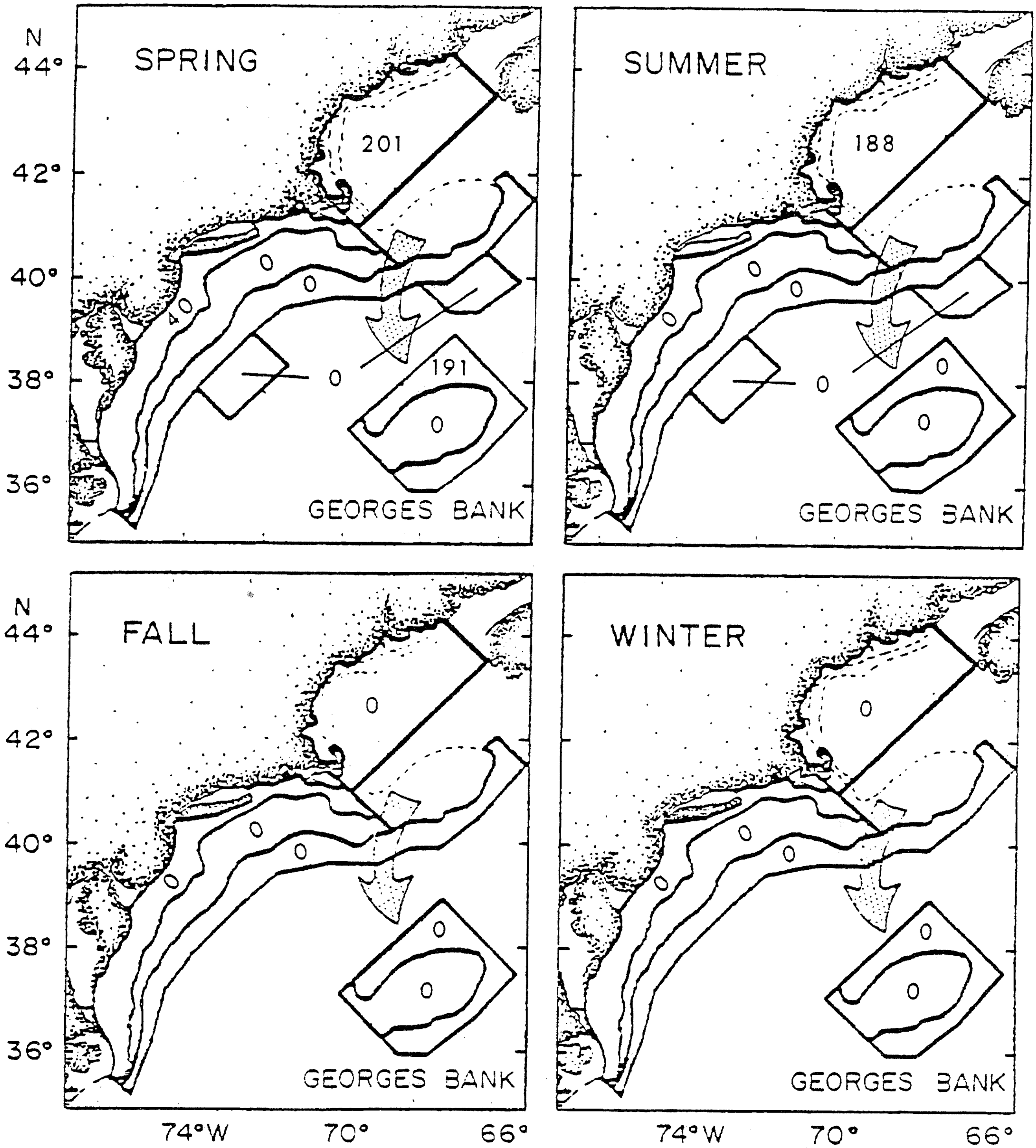

Figure 9g. Estimates of the number of individuals of E. glacialis by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 7. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Eubalaena glacialis*, corrected for diving behavior.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	2.78E-03 1.46E-04 201 ± 368	2.61E-03 1.99E-04 188 ± 463	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
GEORGES BANK	2.47E-03 5.90E-04 170 ± 555	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
<50 FATHOMS	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
>50 FATHOMS	5.20E-03 1.24E-03 191 ± 643	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
LEASE SALE 52	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-ATLANTIC	2.77E-04 2.09E-05 38 ± 151	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEAR SHORE	9.80E-04 7.39E-05 40 ± 152	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-SHELF	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEW YORK BIGHT	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
SHELF EDGE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
CONTINENTAL SLOPE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	. . . ± .	. . . ± .
STUDY AREA OCS*	380 ± 688	148 ± 344	0 ± 0	0 ± 0

*Study area OCS does not include the slope water regions.

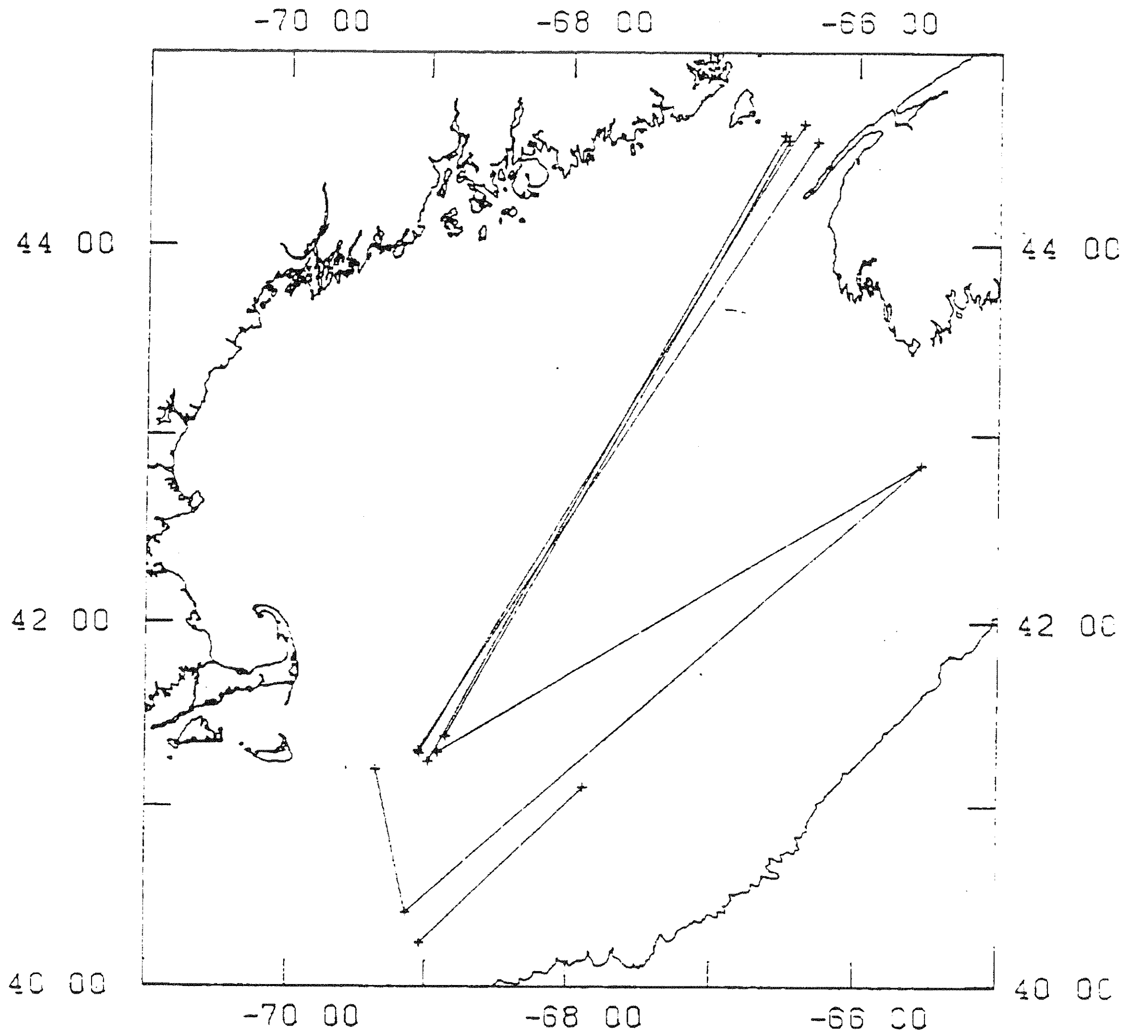

Figure 9h. Resightings within the same calendar year of individual right whales based on bonnet pattern analyses.

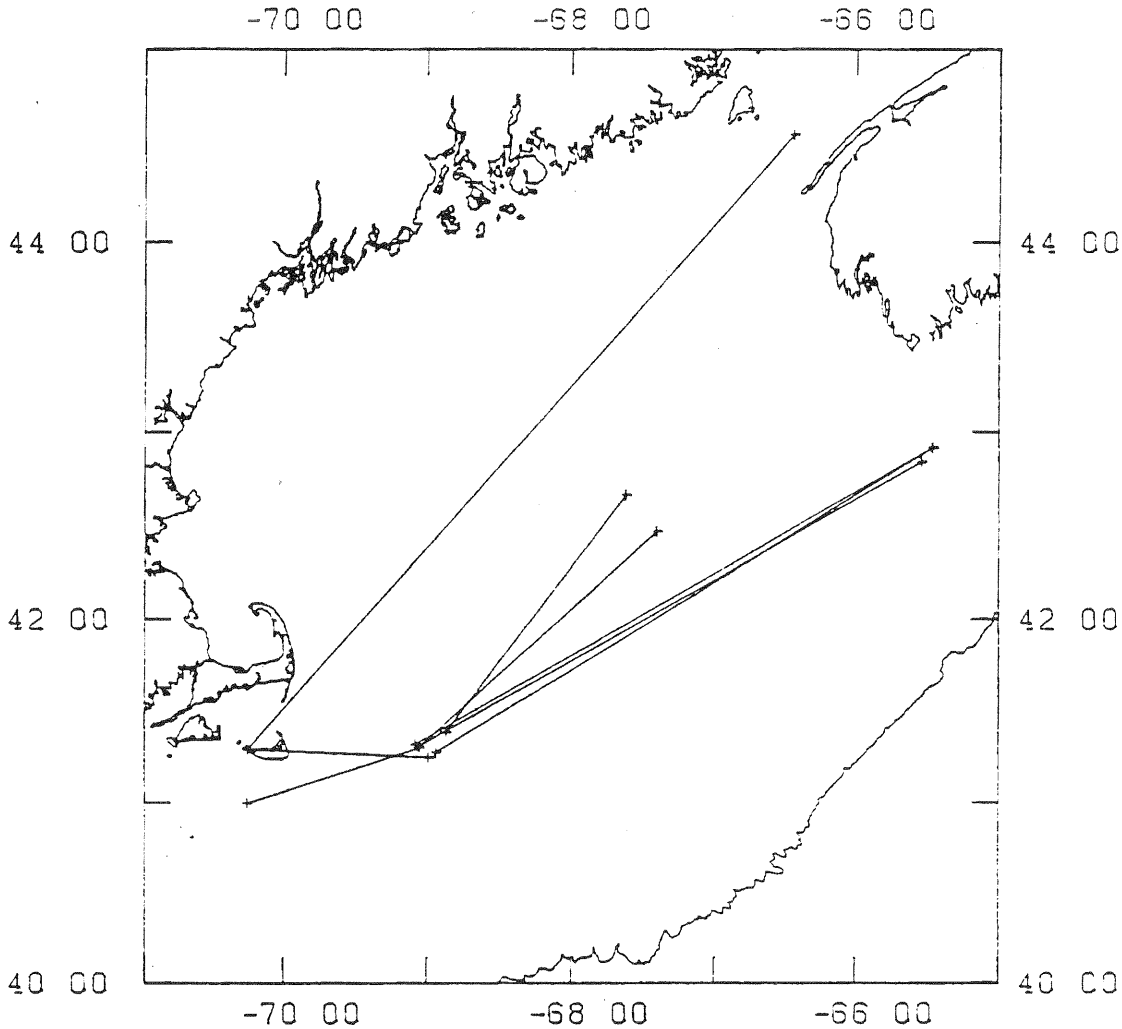

Figure 9i. Resightings between calendar years of individual right whales based on bonnet pattern analyses.

Table 7b. Resightings within the same calendar year of individual right whales based on bonnet pattern analyses. Confidence codes: 1 = sure, 2 = probable. Distance in miles.

DATE	POSITION	CONFIDENCE CODE	DAYS APART	DIST
18 Apr 1980	40°14.4' X 69°02.5'	1	18	86
6 May 1980	41°06.2' X 67°53.7'			
9 May 1981	41°22.9' X 68°52.0'	1	109	237
26 Aug 1981	44°32.5' X 66°29.2'			
21 May 1981	41°18.1' X 69°03.7'	2	100	256
29 Aug 1981	44°32.1' X 66°17.1'			
21 May 1981	41°17.3' X 69°03.3'	2	100	162
29 Aug 1981	44°37.7' X 66°22.9'			
2 Apr 1980	41°11.9' X 69°21.8'	2	17	50
19 Apr 1980	40°24.5' X 69°08.8'	2	121	261
19 Aug 1980	42°50.4' X 65°32.6'			
10 May 1981*	41°14.5' X 68°59.3'	1	108	255
26 Aug 1981	44°34.2' X 66°30.7'			
4 May 1980	41°17.5' X 68°55.5'	1	107	222
19 Aug 1980	42°50.4 X 65°32.6'			

* same animal also seen on 10 June 1979 (Table 7c)

Table 7c. Resightings between calendar years of individual right whales based on bonnet pattern analyses. Confidence codes: 1 = sure, 2 = probable. Distance in miles.

DATE	POSITION	CONFIDENCE CODE	DAYS APART	DIST
31 May 1980	42°28.2' X 67°24.1'	1	356	121
21 May 1981	41°18.1' X 69°03.1'			
23 Aug 1980	42°55.0' X 65°27.8'	1	271	280
21 May 1981	41°18.9' X 69°05.0'			
13 Jun 1980	42°39.9' X 67°37.1'	1	331	108
9 May 1981	41°22.9' X 68°52.0'			
10 Jun 1979	41°17.1' X 70°15.5'	1	700	76
10 May 1981	41°14.5' X 68°59.3'			
19 Aug 1980	42°50.4' X 65°32.6'	2	275	233
21 May 1981	41°18.0' X 69°04.0'			
23 Aug 1980	42°55.0' X 65°27.8'	2	265	231
14 May 1981	41°16.3' X 68°56.2'			
14 Jun 1979	41°17.1' X 70°15.5'	2	430	237
18 Aug 1980	44°33.4' X 66°26.3'			
28 Mar 1980	40°59.6' X 70°15.4'	1	412	81
21 May 1981	41°18.0' X 69°03.0'			
29 May 1980	41°21.4' X 69°12.7'	1	346	21
10 May 1981	41°37.8' X 69°25.4'			
30 May 1980	41°20.9' X 69°05.8'	1	355	16
20 May 1981	41°08.5' X 68°55.6'			

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Megaptera novaeangliae - Humpback whale - Endangered Species

INTRODUCTION

1981 Data. The 1981 data were consistent with the results previously reported in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. *M. novaeangliae* was the the second most commonly sighted large whale in the study area. The 1026 sightings of 2793 individuals accounted for 23% of the large whale sightings and 25% of the baleen whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 2.7, with a mode of 1, and a range from 1 to 27. This small group size was typical of all baleen whales, and for the most part, large whales.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The distribution of the humpback whale is shown in Figures 10a-b. For the most part, humpback sightings are restricted to the northern half of the study area. During the 39 months of surveys, only 6 sightings, for a total of 7 individual humpback whales occurred south of 40°N latitude: 1 in fall, 2 in spring, and 3 in winter. Within the northern portion of the study area, humpback sightings tend to concentrate in a relatively narrow band along the western Gulf of Maine between latitudes 41 and 43°N. Other, less dense concentrations of sightings occurred east and southeast of Montauk Point, Long Island, along the northwestern flank of Georges Bank, and in the northern Gulf of Maine near the mouth of the Bay of Fundy.

The seasonal distribution pattern can be seen in Figures 10c-d. In general, the humpback whale occurs over the northeast U.S. OCS on a three-season basis, from spring through fall. Only 10 winter sightings were reported during the entire survey period. This corresponds to the time of year when much of the western North Atlantic humpback population is found in the Caribbean area (Balcomb and Nichols, 1978; Clark, 1957; Katona et al., 1980; Winn et al., 1975). During the remaining three seasons, the distributional pattern remains relatively constant, with only small differences between seasons. During the summer there are relatively more sightings in the northern Gulf of Maine/Bay of Fundy area than during spring or fall, while in the fall, sightings from Nantucket Shoals westward to Long Island are largely absent.

Feeding. Occurrences of surface feedings mirrored the major concentrations of humpback whale sightings and comprised 13% of the total sightings. The majority of feeding sightings occurred along a corridor stretching from the northern portion of the Great South Channel along the 100 m contour eastward of Nantucket Shoals, and continuing inside the 100 m contour to Jeffreys Ledge (Fig. 10e). A second area of numerous feeding sightings was located east of Montauk Point. No feeding sightings were made over the deeper interior portions of the Gulf of Maine, although general sightings indicate humpbacks are commonly found along the shallower inshore areas. Some 88% of surface feeding sightings occurred during spring and summer periods.

Based on shipboard observations, a particularly important food item for humpbacks appears to be the sand lance, *Ammodytes* sp. This is in agreement with Overholtz and Nicolas (1979) and Hain et al. (1982), who observed feeding humpbacks in association with dense schools of sand lance. It is of interest to note that Sherman et al. (1981) reported *Ammodytes* spp. comprised some 94% of ichthyoplankton on Georges Bank in the years 1976-79.

There were no surface feeding sightings directly within any of the existing or proposed Lease Areas. However, there were several general sightings in Lease Areas, particularly Proposed Area 52 and Area 42. Since these areas are regions of high productivity (O'Reilly and Busch, 1982), and high *Ammodytes* spp. abundance (Sherman et al., 1981), it is possible that feeding by humpbacks does occur within the Lease Areas mentioned above. It is also important to note that the Great South Channel, with its demonstrated importance to humpback feeding, lies directly to the northwest of Areas 42 and Proposed Area 52.

Calves and Juveniles. During the three year survey period, 110 sightings of humpback whale calves or juveniles were reported. Figure 10f shows their distribution. All of these sightings were found between Long Island and the Bay of Fundy; most were concentrated in coastal waters surrounding Cape Cod. The number of calf sightings reached a peak during spring months (50 sightings) and the distribution during that time was restricted to the area between Jeffreys Ledge and Long Island. Calf sightings were almost as numerous during the summer seasons (41 sightings). During this season calves were seen farther north off the coast of Maine and in the Bay of Fundy. During the fall months, there were fewer calf sightings (19 sightings), which were restricted almost exclusively to Stellwagen Bank. No calves were seen during the winter months.

The spatial and temporal distribution patterns of humpback whale calves generally mirrored those of the population as a whole. Goodale (1982) found that the geographic distributions of calves and other age classes did not differ statistically, however the average water depth for humpback calf sightings was significantly lower than that for other age classes (23.1 m difference, $p<0.01$).

Humpback calves were generally associated with small groups of 2-3 animals, but in some cases calves were found among adult groups numbering as many as 20 animals. Six instances of apparent nursing were reported; five of these occurred during the spring near Stellwagen Bank, and one occurred during the summer in the Bay of Fundy.

No sightings of humpback calves were reported from BLM Lease Sale Areas 40, 42, 49, or 59, or from Proposed Lease Sale Area 52.

Areas. The Great South Channel, the Provincetown Slope, Stellwagen Bank, and Jeffreys Ledge, all in the western Gulf of Maine, were the locations of major concentrations of humpback whales during spring, summer, and fall seasons. These areas correspond to the distribution of dense populations of sand lance (*Ammodytes americanus*) (Meyer et al., 1979). It seems probable that humpback distribution in the Gulf of Maine is determined primarily by prey availability.

One humpback whale was sighted in March 1979 in Lease Sale Area 59; none were reported from Areas 40 or 49. Five sightings were reported from proposed Lease Sale Area 52: in May 1979, August 1979, April 1980, August 1980, and May 1981. The last three of these also fall within Area 42. The area of dense concentration of humpback sightings in the Great South Channel extends to within 70 km of proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 8 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 10g. The peak average abundance estimate for humpback whales in the Study Area was 658 (+/590) and occurred during spring. The maximum point estimate of abundance for this species was 760 (+/- 1309) in sampling block A during June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 827 (+/- 2266) in sampling block A, stratum z, in July 1979. These estimates have been adjusted for animal diving behavior using the behavioral data collected from shipboard during 1980 and 1981. For a detailed discussion of these data see Special Topic D, Section IV, this report. The maximum point estimate represents approximately 41% of the estimated 2000 or more humpbacks that seasonally inhabit waters in the West Indies (Scott and Winn, 1980) and represents 70% of the total number of catalogued individuals in the western North Atlantic (Katona et al., 1980).

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 153 sightings of this species. The average water temperature for humpback whale sightings was 10.9°C, the second coolest found for all baleen whale species; the mode was 8.0 with a range from 4.5 to 21.0°C. Ninety percent of these sightings occurred in cold to moderately warm water (6.0 to 18.1°C).

Depth (m). The average depth for humpback sightings was 95m, with a mode of 53, and a range from 4 to 2195m. This mean depth was the shallowest found for all baleen whales. Ninety percent of all sightings occurred in a relatively shallow depth range (20 to 174m). This corresponds well to the inshore distribution of humpbacks, especially near Cape Cod and Stellwagen Bank.

Non-parametric statistical comparisons between 1979/80 dedicated aerial humpback sightings and random geographic points showed, despite a small sample size, some statistical support for the hypothesis that humpback whales occur preferentially in shallow water (1980 CETAP Report). Unfortunately, the 1981 data could not be added to increase the sample size due to non-equivalence of the areas sampled. The same tests also supported, with better significance levels, the hypotheses that humpbacks are preferentially distributed in waters near shore and over steeply sloping bottom topography.

Associations. Multispecies associations involving one or more of 13 cetacean species were reported in 28% of sightings of humpback whales. B.physalus, L.acutus, and B.acutorostrata, arranged in decreasing order of occurrence, were the most commonly observed species in these associations. Individually or in combination, these 3 species accounted for 59% of humpback whale multispecies sightings with B.physalus alone accounting for 34% of the total. Of the less frequently observed species seen with humpback whales, unidentified dolphins, unidentified whales, and E.glacialis, (in decreasing frequency) were the most numerous (refer to Table 30, for details).

Of the 289 multispecies sightings involving humpback whales, at least 80 of these occasions or roughly 28% of the total were reported within areas of feeding-associated activities i.e., the presence of birds, baitfish, or bubbles. It is also worth noting that calves or juveniles of M.novaeangliae were observed during 54 of the 289 multispecies sightings for this species.

Migration and Movement. The data provide little direct evidence concerning humpback migration. Humpback whales are known to follow a general north-south pattern of migration between tropical breeding areas and temperate feeding grounds (Clark, 1957; Dawbin, 1966), and photographic identification of individual whales has firmly demonstrated the correspondence between Caribbean and Gulf of Maine humpbacks (Katona et al., 1980; Katona, 1982). The notable lack of sightings in the southern portion of the study area suggests that whales moving into the Gulf of Maine from their Caribbean winter range do so in deeper water beyond the edge of the continental shelf. Winn and Scott (1979) suggested such an offshore migration route. A summary of sightings in the 1979 CETAP Annual Report and entries in the logbooks of Yankee whaleships (Martin, 1980) both support this contention.

There is some indication in the sighting data of a movement from the area of densest sighting concentration in the western Gulf of Maine to the more northern Gulf and Bay of Fundy area during the summer months. Eastern Atlantic sand lance (Ammodytes marinus) exhibit a late summer dormant period, when they largely remain burrowed into the sandy bottom (Winslade, 1974). Although no corresponding data exist for western Atlantic Ammodytes, if late summer dormancy does occur, then the increase in humpback numbers in the northern Gulf of Maine might represent a dispersal in search of alternate prey when their primary prey species declines in availability.

Respiration and Dive Times. A total of 45.2 hours of observations of the surface and diving behavior of 56 individual humpback whales were recorded from the R/V Tioga during May 1980 and May 1981. The duration of single surface behavioral acts ranged from 1 sec to 21.7 min, with a median value of 6.0 sec. Dives ranged in length from 1 sec to 10.1 min, with a median of 16.0 sec. The median length of surface activity bouts was 0.69 min. This value was significantly shorter than the median for right whales, but did not significantly differ from the fin whale value. The median inter-bout dive duration was 1.53 min, significantly shorter than the medians for both fin and right whales. Humpbacks spent a median of 28% of their total time budget engaged in surface activity bouts, which was significantly lower than the percentage for right whales, but did not differ from that for fin whales. The median respiration rate observed was 68/h, which was not significantly different from either the fin or right whale value. Similar sets of values were calculated and compared for various social categories of humpback whales, including solitary whales, whales in pairs or trios, whales engaged in surface feeding, calves, and cows accompanying calves. No significant differences among the social categories were found for surface activity bout duration, inter-bout dive duration, or respiration rate. For the percentage of the total time budget spent in surface activity, the only significant difference found was between the values for calves (65%) and solitary individuals (24%). (See Special Topic D, this volume for detailed treatment.

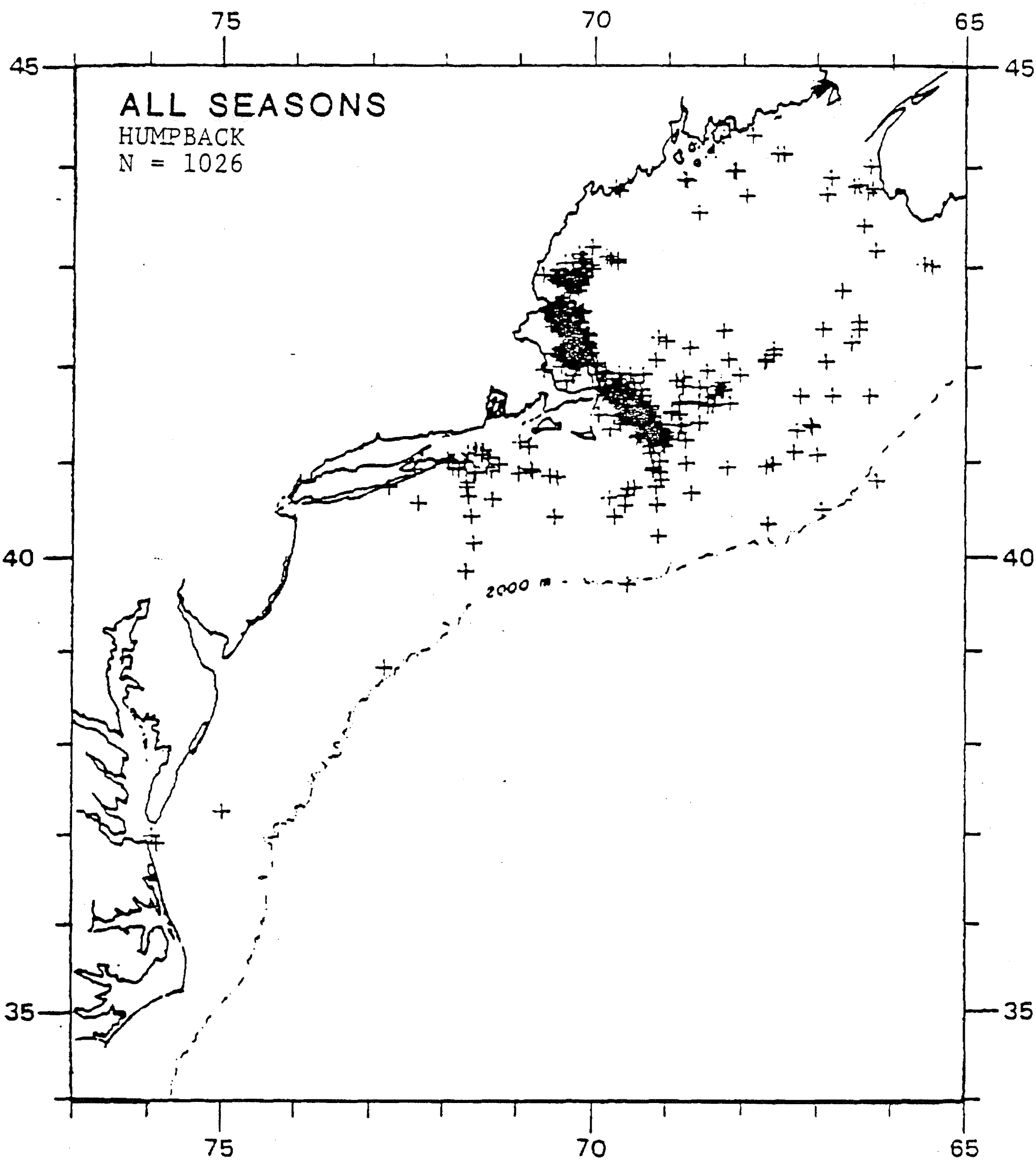

Figure 10a. All sightings of the humpback whale, Megaptera novaeangliae, for the 39 month period -- 1 November 1978 through 28 January 1982.

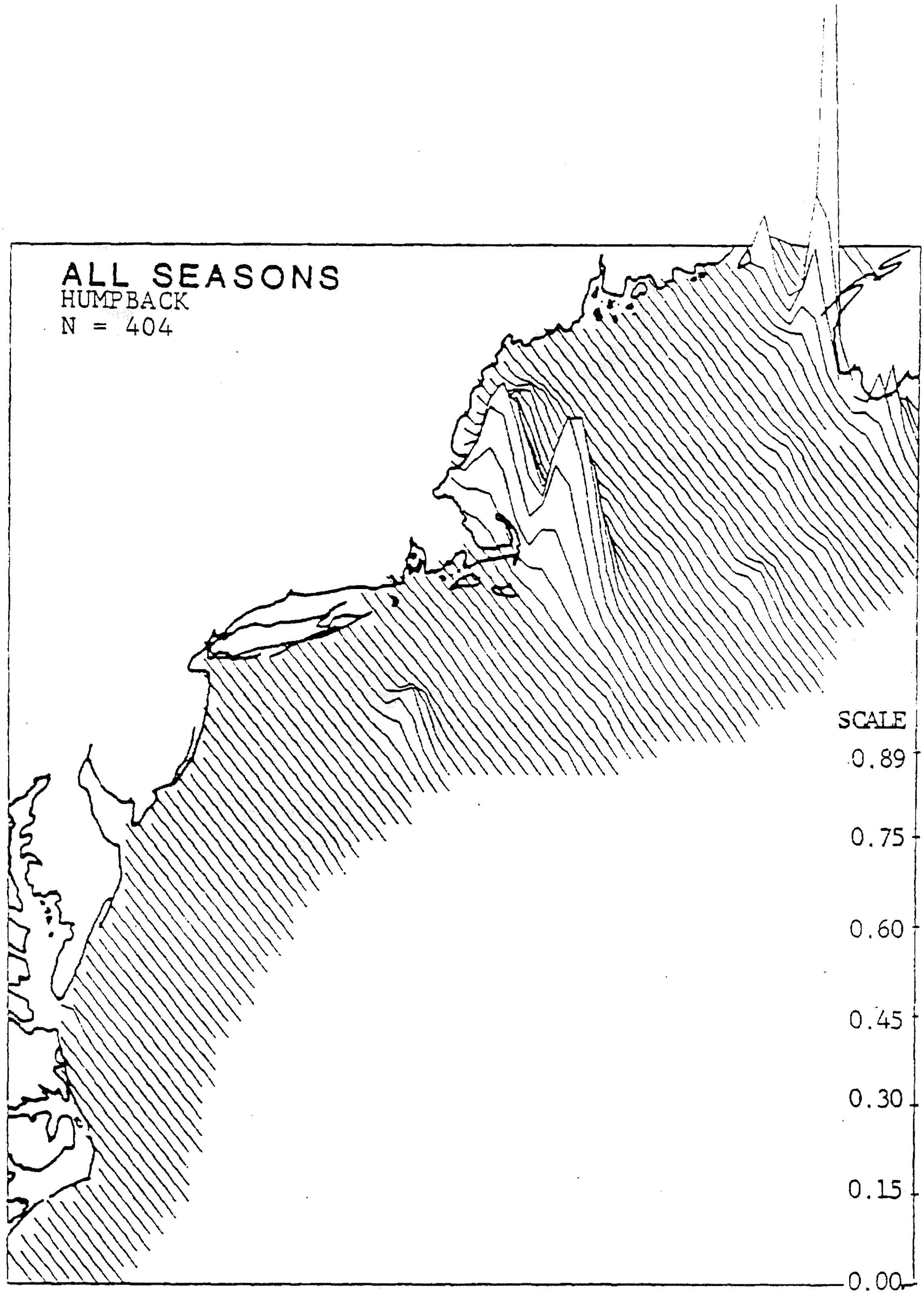

Figure 10b. The relative abundance of M. novaeangliae for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

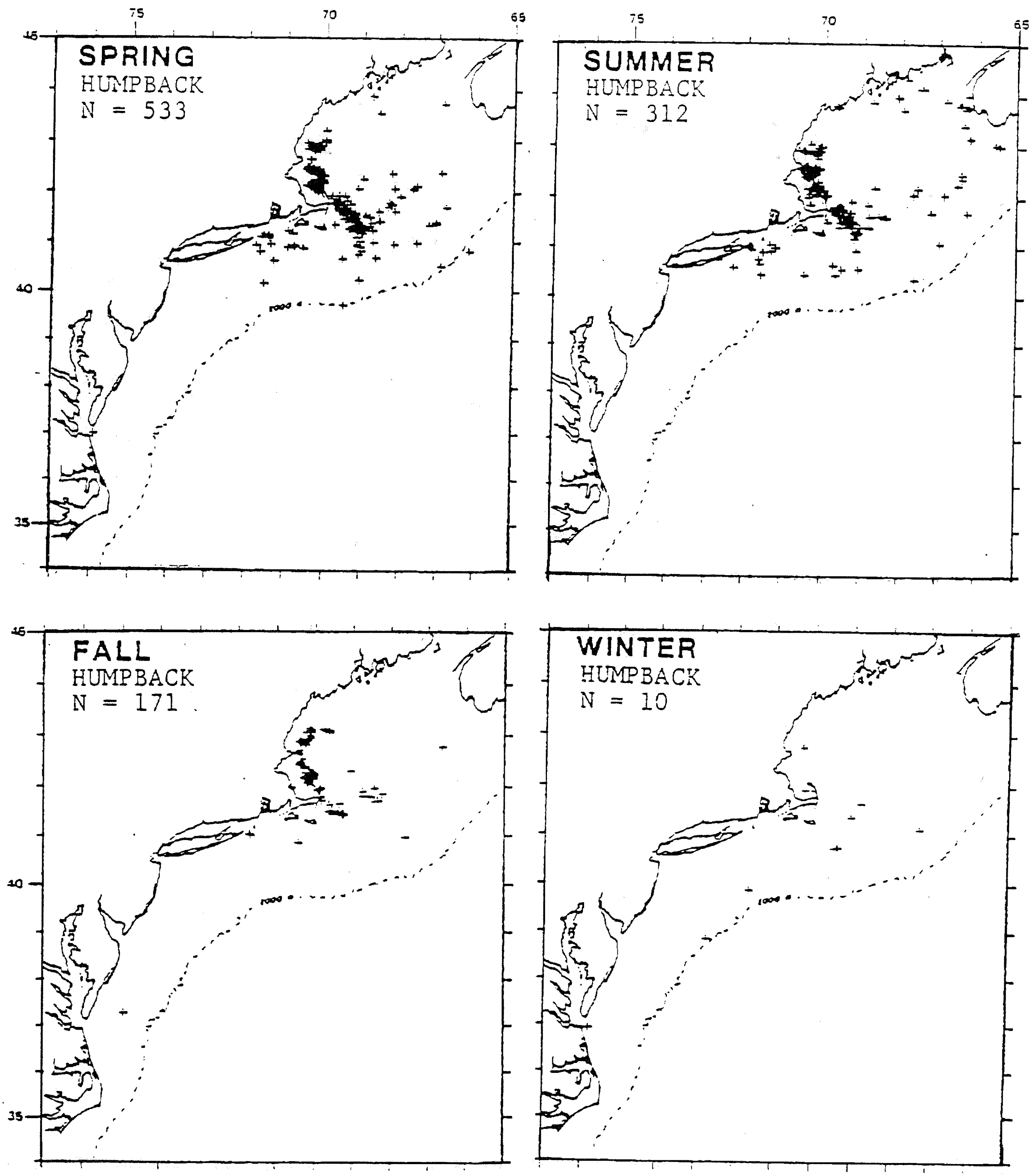

Figure 10c. The sighting distribution of M. novaeangliae by season.

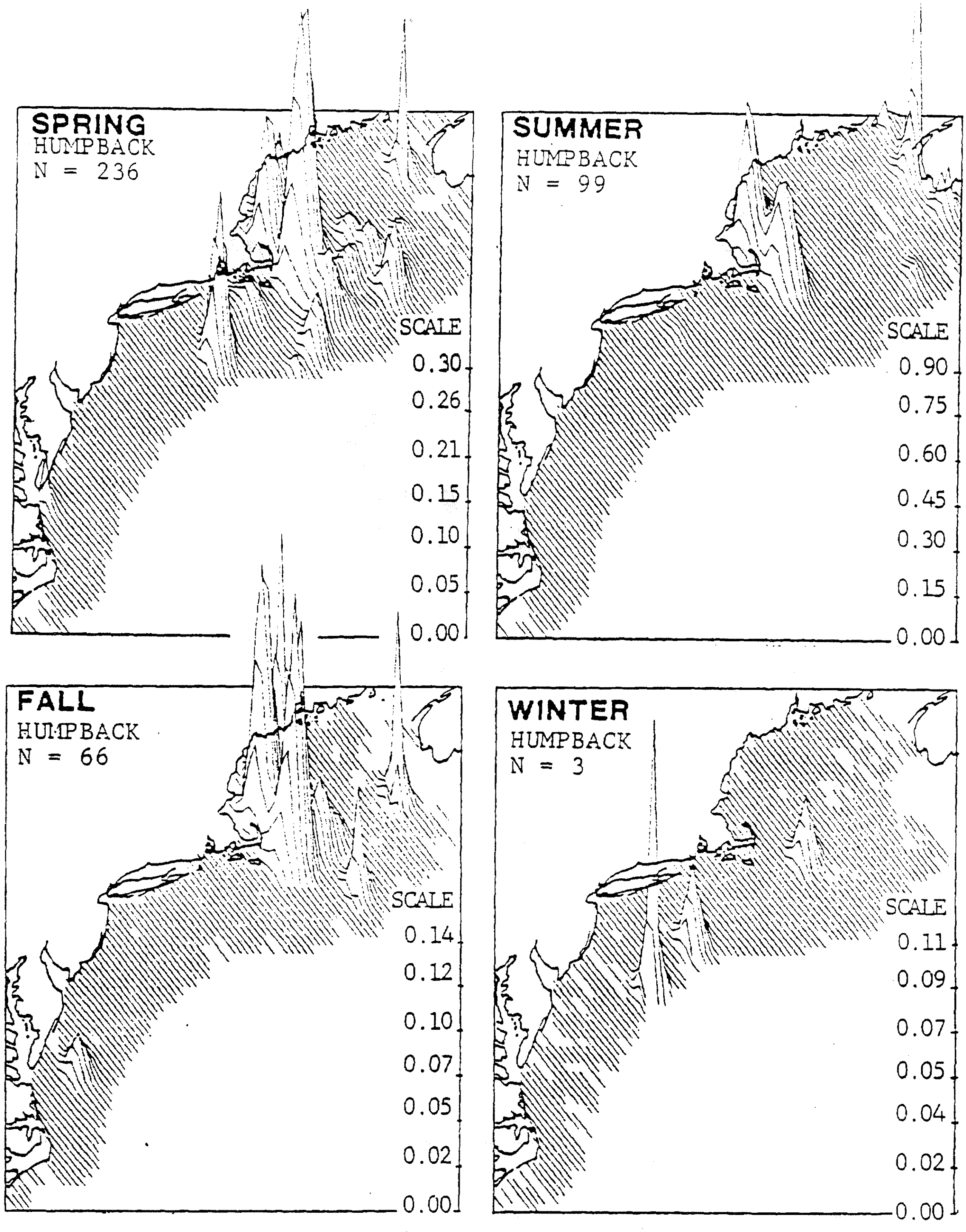

Figure 10d. The relative abundance of M. novaeangliae by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

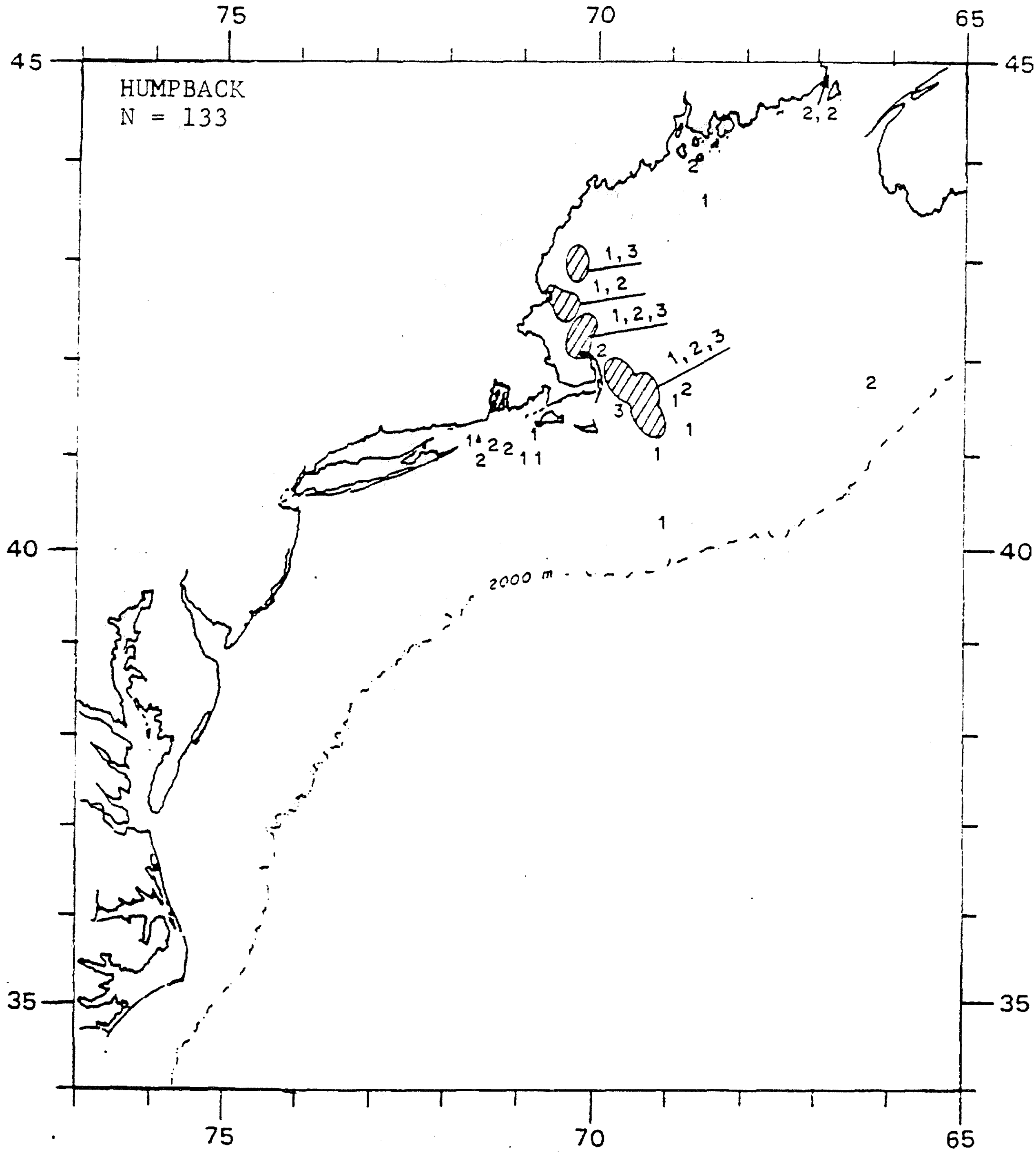

Figure 10e. Sightings of feeding or apparent feeding of _M. novaeangliae_. Single and widely separated observations are denoted by a number indicating the season in which the sighting occurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations were concentrated in an area, the area has been enclosed by a lined region and the seasons of included observations are shown on the adjoining line.

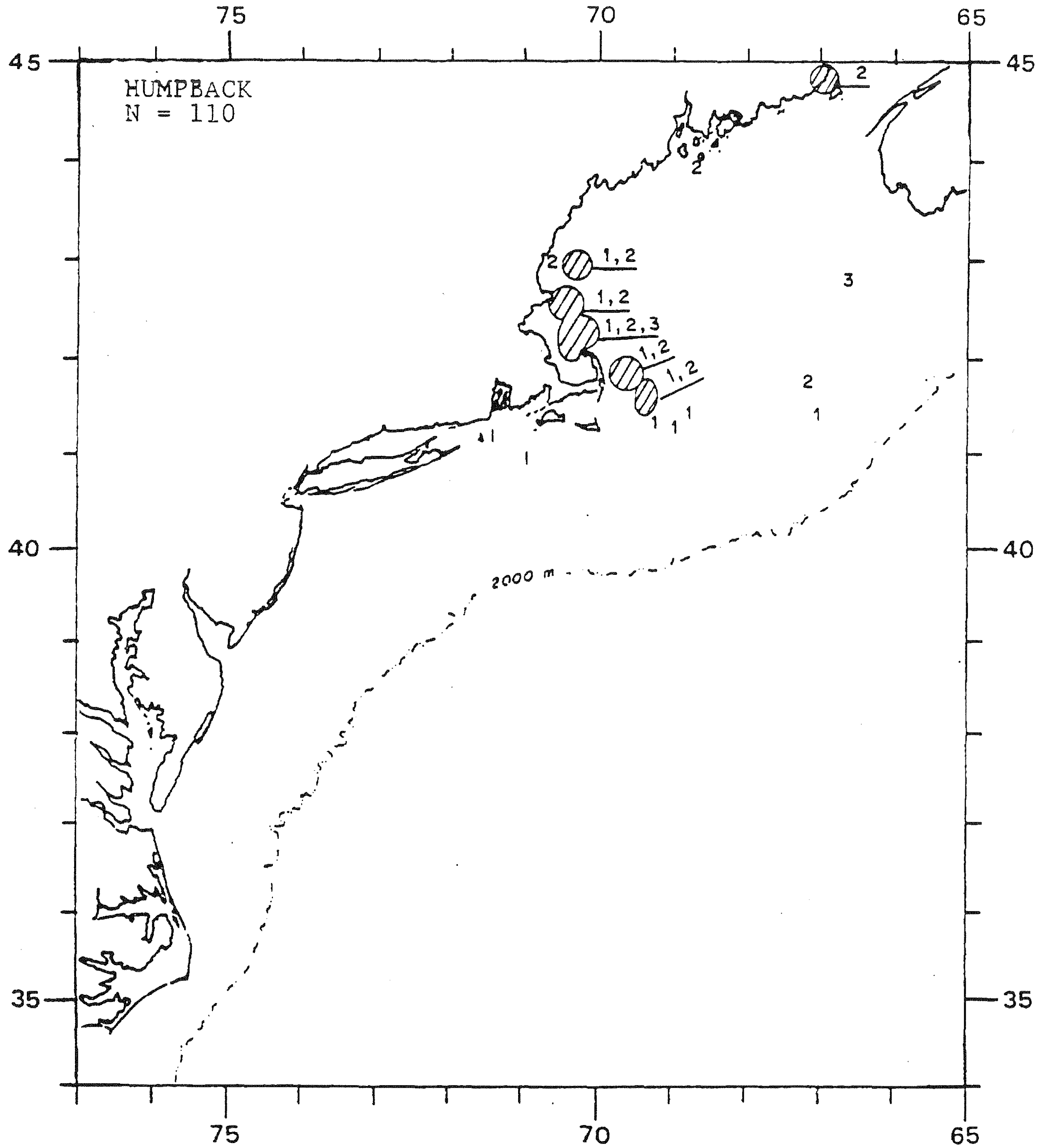

Figure 10f. Sightings of calves or juveniles of M. novaeangliae. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

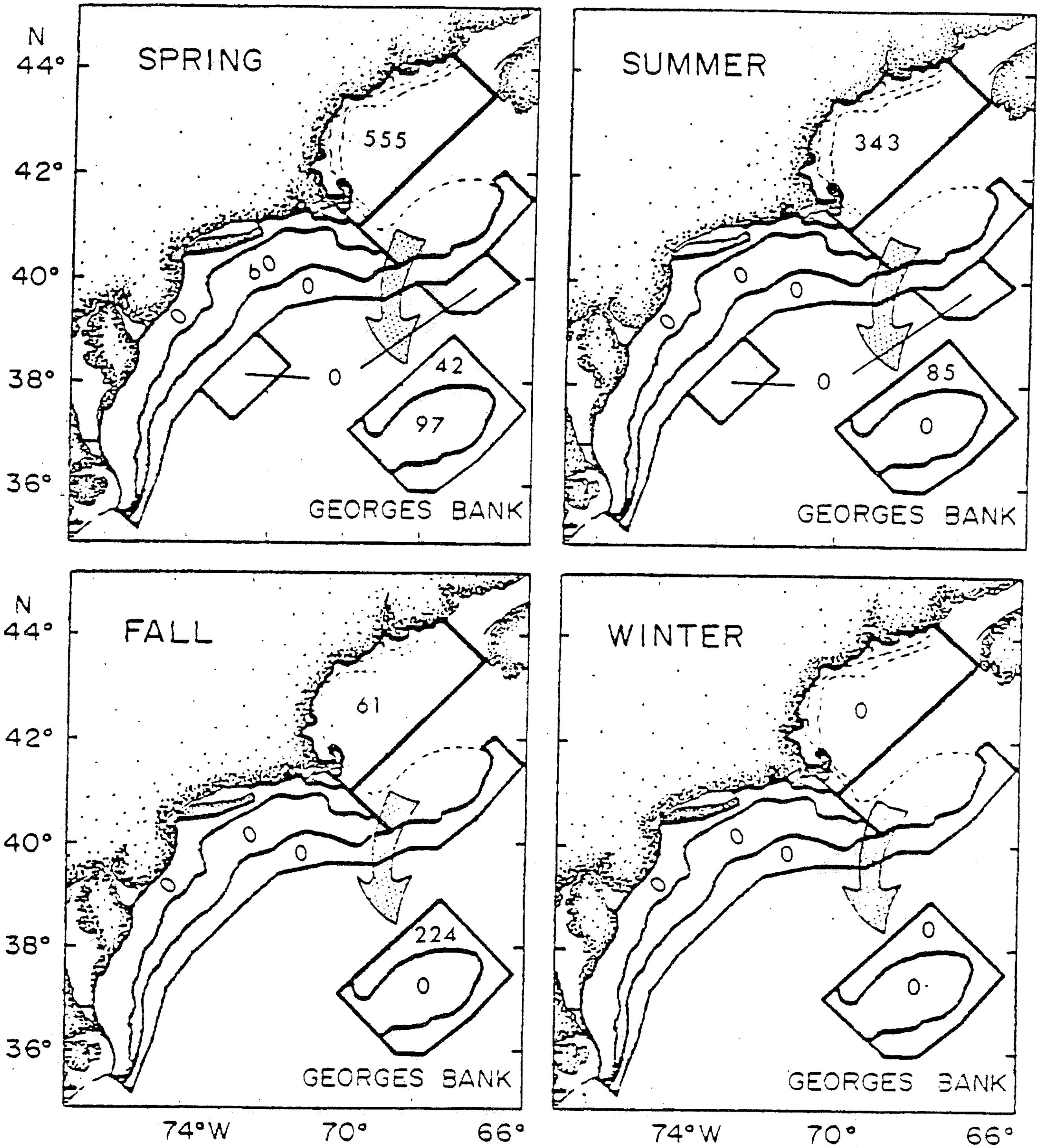

Figure 10g. Estimates of the number of individuals of M. novaenangliae by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 8. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Megaptera novaeangliae*, corrected for diving behavior.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	7.70E-03	4.75E-03	8.43E-04	0.00E+00
	5.81E-04	7.99E-04	2.37E-05	0.00E+00
	555	343	61	0
	± 734	± 927	± 194	± 0
GEORGES BANK	2.11E-03	1.07E-03	3.46E-03	0.00E+00
	1.00E-04	5.79E-05	1.41E-04	0.00E+00
	146	74	239	0
	± 229	± 200	± 630	± 0
<50 FATHOMS	3.00E-03	0.00E+00	0.00E+00	0.00E+00
	1.25E-04	0.00E+00	0.00E+00	0.00E+00
	97	0	0	0
	± 185	± 0	± 0	± 0
>50 FATHOMS	1.14E-03	2.30E-03	6.11E-03	0.00E+00
	7.37E-05	1.25E-04	2.49E-04	0.00E+00
	42	85	224	0
	± 157	± 227	± 718	± 0
LEASE SALE 52	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-ATLANTIC	4.98E-04	0.00E+00	0.00E+00	0.00E+00
	1.16E-05	0.00E+00	0.00E+00	0.00E+00
	68	0	0	0
	± 113	± 0	± 0	± 0
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	1.14E-03	0.00E+00	0.00E+00	0.00E+00
	2.66E-05	0.00E+00	0.00E+00	0.00E+00
	60	0	0	0
	± 117	± 0	± 0	± 0
NEW YORK BIGHT	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
SHELF EDGE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	658	351	175	0
	± 590	± 723	± 322	± 0

*Study area OCS does not include the slope water regions.

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Balaenoptera physalus - Fin whale - Endangered Species

INTRODUCTION

1981 Data. The 1981 data were consistent with the results previously reported in 1979 and 1980. The sections below describe the cumulative results for all years.

Number of Sightings. *B. physalus* was the most commonly sighted large whale in the study area. The 2047 sightings of 5875 individuals accounted for 47% of the large whale sightings and 51% of the baleen whale sightings during the 3 year survey period. These sighting percentages are slightly lower than those calculated by Mitchell (1974) from results of surveys in 1966-71, which showed that fin whales comprised approximately 58% of all whales sighted over the continental shelf between 57°N (Labrador) and 42°N (Cape Cod).

Individuals per Sighting. The average number of individuals per sighting was 2.9, with a mode of 1, and a range from 1 to 65. This small group size was characteristic of all baleen whales, and for the most part, large whales.

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General Distribution. The fin whale is commonly and widely distributed both spatially and temporally over the northeastern U.S. OCS (Figures 11a-d). Spatially, the species occurs in nearly all areas of the OCS, but tends to occupy the shelf proper rather than the shelf edge - a characteristic it shares with the other baleen whales. The species is present in most areas on a four season or year-round basis, with the probable exception of the northern Gulf of Maine in the winter and early spring.

The seasonal fluctuation in number of sightings seen in many other cetacean species is also evident in fin whales, and to much the same degree. The number of sightings ranges from 51 in winter (2% of total sightings) to 1023 in spring (50% of total sightings). However, when a correction for a similarly varying sighting effort is made, as in Figures 11c-d, the relative abundance of fin whales across the seasons is seen to be somewhat more uniform. This conclusion was advanced in the 1980 CETAP Annual Report and is supported by the cumulative 3 year data. Particularly noteworthy is the presence of fin whales in the Cape Ann to Cape Cod area, and around Georges Bank, through the winter season at relative abundance levels comparable to other seasons. The areas of Jeffreys Ledge, Stellwagen Bank, and immediately east of Cape Cod are distinctive, however, and clearly experience an increase in fin whale abundance in the spring and summer seasons. The cumulative data also bear out an additional observation from the 1980 CETAP Annual Report. That is, the relative abundance levels are increased in winter and spring in the area east of the Delaware Peninsula and the mouth of the Delmarva Bay. Based on these data, it is hypothesized that, while fin whales are present in this area year round, it is particularly important as a winter and spring habitat.

Feeding. Sightings of surface feeding fin whales were spread throughout the study area, as were the general sightings, and comprised 14% of the total sightings. There were two distinct areas of heavy feeding, mirroring the heaviest concentrations of general fin whale sightings (Fig. 11e). The largest major feeding area was the corridor reaching from the Great South Channel to Jeffreys Ledge, centered primarily along the 100 m contour, but extending into both shallower and deeper waters. The second major area of feeding sightings was directly east of Montauk Point. Feeding sightings were made as far north as the Bay of Fundy, and as far south as approximately 37°30' N, off the Delmarva peninsula.

Eighty-nine percent of the feeding sightings were made during spring and summer. Although the two major areas described above were represented in both time periods, the number of sightings decreased in the Great South Channel and increased off Montauk Point during the summer. The fewer feeding sightings in the Great South Channel/Georges Bank region during summer may reflect a movement in dominant prey items of the fin whale, particularly *Ammodytes* spp., due perhaps to drift patterns associated with summer currents. The summer surface flow pattern on Georges Bank is clockwise, with the westerly flow over the southern portion of Georges Bank drifting across the Great South Channel (Bumpus, 1976). Such a drift could, in fact, redistribute segments of the Georges Bank plankton and ichthyoplankton community to the west, i.e., towards Southern New England waters and Long Island. Data collected on herring larvae show just such a drift pattern, although the herring data was collected in late fall/early winter months, presumably before the winter breakdown of the clockwise gyre (Bumpus, 1976).

Fin whales are euryphagous in the Northern Hemisphere, feeding on euphausids, copepods, and schooling fishes, depending on their respective availability (Mitchell, 1974). In our study area, schooling fishes appear to be the primary diet item (Katona et al., 1978; Watkins and Schevill, 1979; Overholtz and Nicolas, 1979). In previous years herring (Clupea harengus) was probably the major diet item, but given the recent decline in herring (Sherman et al., 1981), sand lance may now be the dominant food item for fin whales in the study area. Also, our observations include only surface feeding and thus it must be supposed that feeding occurs at other times and places than can be shown only with surface feeding observations.

There were several feeding sightings within the Lease Areas, including Areas 40, 49, 59, 42, and Proposed Area 52. This is in agreement with the numerous general sightings within the Lease Areas. Also of importance is the concentration of feeding sightings in the Great South Channel to the northwest of Area 42 and Proposed Area 52.

Calves and Juveniles. During the three year survey period, 100 sightings of fin whale calves or juveniles were reported (Figure 11f). Calves were found mostly in shallow coastal waters with sighting concentrations along Stellwagen Bank and near the Great South Channel. Although fin whale adults were sighted from Cape Hatteras to the Bay of Fundy, calves were found only from Maryland to Jeffreys Ledge. Calf sightings were distributed throughout this latitudinal range during the spring (59 sightings) and summer (29 sightings). The 9 calf sightings reported during the fall were restricted to the area around Cape Cod. Only 3 sightings were found during the winter (1 on Stellwagen Bank and 2 east of New Jersey along the continental shelf).

Fin whales are probably born during winter (Mitchell, 1974); the peak of calf sightings found during spring months may be due to the birth of animals just prior to that time. Alternatively, the observed concentration of calves near Cape Cod, especially during the spring, may be an artifact of the intensive sighting effort which resulted from the Endangered Species Surveys. The absence of calf sightings north of Jeffreys Ledge during the summer is surprising since Kraus and Prescott (1981) found fin calves in the Bay of Fundy during July and August. The consistency and relatively wide range in the latitudinal distribution of sightings during spring and summer suggest either that calves are born at many different locations or that they disperse widely after parturition.

Fin calves were found mostly among small adult groups of 2-4 animals, although groups as large as 20 animals were seen with calves. Goodale (1982) found that the average seawater temperature was significantly warmer for calf sightings than for non-calf sightings (1.9°C difference: $p=<0.05$). Since the proportion of calf to total sightings remained relatively constant throughout the year, this tentatively suggests a discontinuity in finback distribution between calf and non-calf groups.

During the spring, one calf sighting was found within BLM Lease Sale Areas 40, 49, and 59. During each of the four seasons, one or two calf sightings were found within Proposed Lease Sale Area 52. No calves were found within Lease Sale Area 42.

Areas. In the mid-Atlantic, the fin whale occurs commonly and is widespread in Lease Sale Areas 40, 49, and 59. To date, this occurrence is almost completely limited to the spring and summer, with only two wintertime occurrences in, or at the boundary of, the west central portion of Areas 40 and 49. In the North Atlantic, the fin whale is again common and widespread throughout Lease Sale Area 42 and Proposed Lease Sale 52. When the correction for sighting effort is made, this occurrence is at relatively uniform abundance levels over all seasons. The fin whale and sperm whale are the most common cetaceans found in Proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 9 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 11g. The peak average abundance estimate of fin whales in the Study Area was 5423 (+/- 3141) and occurred during the spring. The maximum point estimate of fin whale abundance was 6043 (+/- 70497) in sampling block A during June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 4764 (no CI) in sampling block A, stratum y, in June 1979. These estimates have been adjusted for diving behavior based on the behavioral samples taken from shipboard in 1980 and 1981. Both the maximum point estimates and the peak average abundance estimate for the Study Area exceed the estimate of 2000 individuals presented by Sergeant (1977) for the Nova Scotia management stock.

Morphometric Analysis. A morphometric analysis of fin whales seen within the CETAP study area used vertical aerial photography to record whale images for later photogrammetric measurement. Allometric growth curves and length frequency distributions were developed for the sampled finbacks which, together with age/length keys, enabled estimation of population parameters such as annual calf production rate (.07 to .38) and annual reproductive rate (.28 to .55). Several relative age distributions created from photogrammetric data using age/length keys were examined. A simple box model relating immigration, calf production, emigration and total mortality suggested that no strong departure from stability in numbers can be discerned for the fin whale population in the study area. For a complete analysis see the CETAP 1980 Annual Report.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 475 sightings of this species. The average water temperature for fin whale sightings was 12.8°C, the warmest found for all baleen whales; the mode was 8.0, with a range from 1.3 to 25.8°C. Ninety percent of all sightings were found in a wide water temperature range (6.0 to 22.6°C). This may be explained by the wide latitudinal range of fin whale sightings.

Depth (m). The average depth for fin whale sightings was 149m, the second deepest found for all baleen whales; the mode was 55, with a range from 4 to 2911m. Ninety percent of all sightings were found in a relatively shallow depth range (27 to 256m). This corresponds well to the concentration of fin whales in coastal waters and over the continental shelf.

BEHAVIOR

Associations. Multispecies cetacean aggregations were reported for 18% (369 occasions) of all fin whale sightings. M.novaeangliae was the most common species seen in association with fin whales, but frequent observations with L.acutus and B.acutorostrata were also reported (for details, refer to Table 30, page 418). Alone and in combination, these 3 species accounted for 63% of all fin whale associations. Additionally, 40% of all fin whale multispecies sightings (149 occasions) occurred in areas of inferred feeding activity as determined by the presence of fish, birds, and actual feeding observations. At least 2 other large whale species including *E.glacialis* and at least 6 small whales including *P.phocoena*, *G.griseus*, *D.delphis*, and *T.truncatus* were less frequently observed in association with *B.physalus* as noted in Table 30.

Migration and Movement. The data suggest at least one migration pattern for the fin whale. The high levels of winter/spring abundance off the Delmarva Peninsula decrease at the same time as abundance levels in several locations in New England waters increase to high summer/fall levels. This may reflect a general northward shift of a portion of the population in the spring, and a southward return in the fall. While evidence for migrations in other areas is lacking, it is important to note that the regions which appear to contain a relatively constant number of fin whales year-round may not always be occupied by the same individuals. A relatively static abundance may overlie a condition of dynamic immigration and emigration, and while the number of fin whales in a given region remains relatively constant, there may be an exchange of individuals taking place. To what degree this occurs, or if it occurs, is presently not known.

In Canadian and Icelandic waters, conventional tagging as well as more recent radio-tagging studies have shown that at least some individual fin whales undergo lengthy migrations or movements (Mitchell, 1974; Ray et al., 1978; Watkins, 1981). However, smaller or more localized movements may be more the norm (Mitchell, 1974; Sergeant, 1977). No comparable data are available for the CETAP study area.

In summary, the present CETAP data suggest a possible north-south shift superimposed upon an overall, uniform level of continental shelf occupation which itself may be dynamic in nature.

Respiration and Dive Times. A total of 19.7 hours of observations of the surface and diving behavior of 24 individual fin whales were recorded from the R/V Tioga during May 1980 and May 1981. The duration of single surface behavioral acts ranged from 1 sec to 1.1 min, with a median value of 5.0 sec. Dives ranged in length from 1 sec to 8.9 min, with a median of 13.0 sec. The median length of surface activity bouts was 0.86 min. This value was significantly shorter than the median for right whales, but did not significantly differ from the humpback whale value. The median inter-bout dive duration was 2.38 min, significantly shorter than the median for right whales, but longer than that for humpbacks. Fin whales spent a median of 25% of their total time budget engaged in surface activity bouts, which was significantly lower than the percentage for right whales, but did not differ from the humpback percentage. The median respiration rate observed was 70/h, which was not significantly different from either the humpback or right whale value. Only solitary fin whales were sampled successfully, so no comparisons among social categories were possible. (See Special Topic D, this volume for detailed treatment).

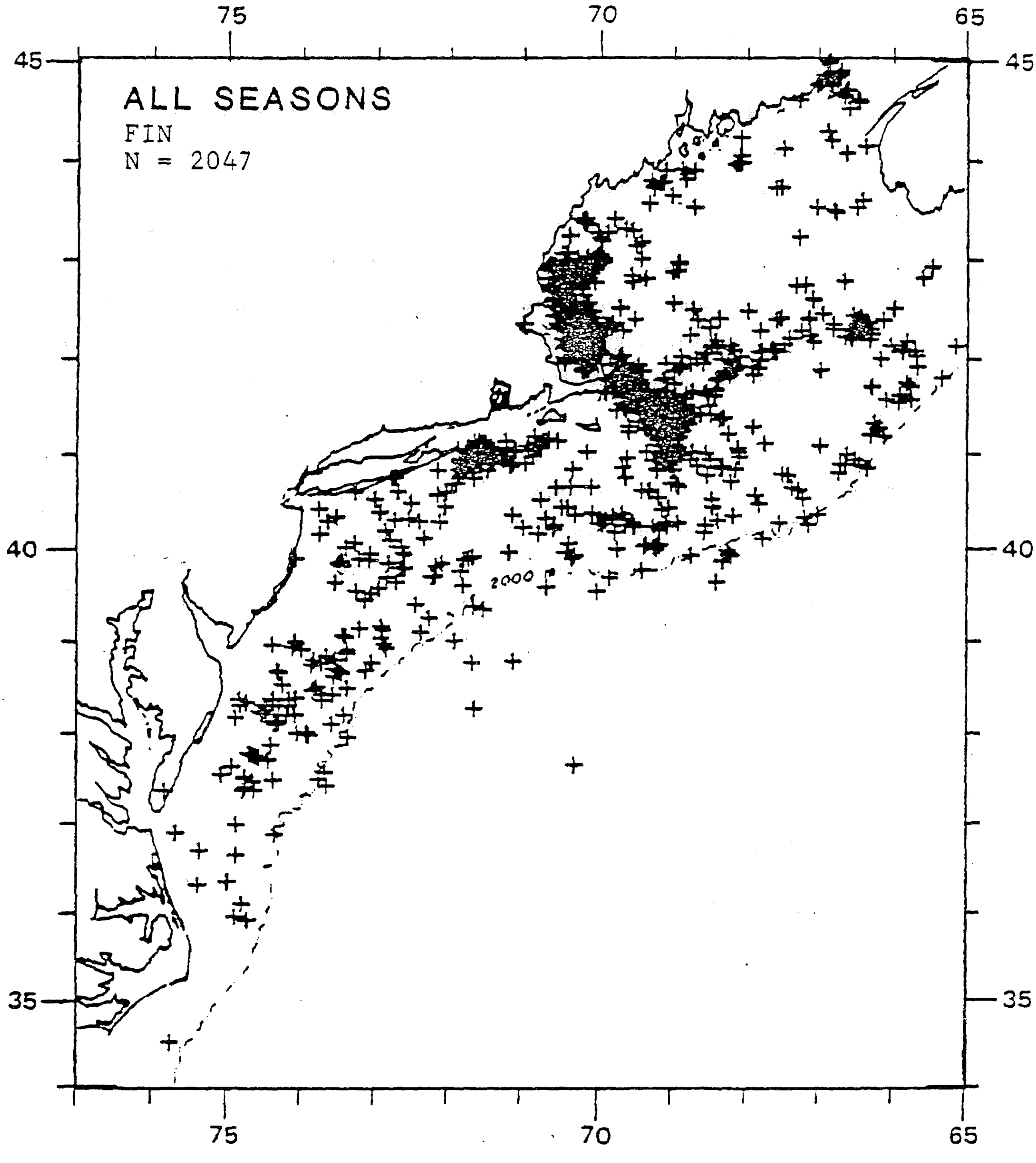

Figure 11a. All sightings of the fin whale, *Balaenoptera physalus*, for the 39 month period -- 1 November 1978 through 28 January 1982.

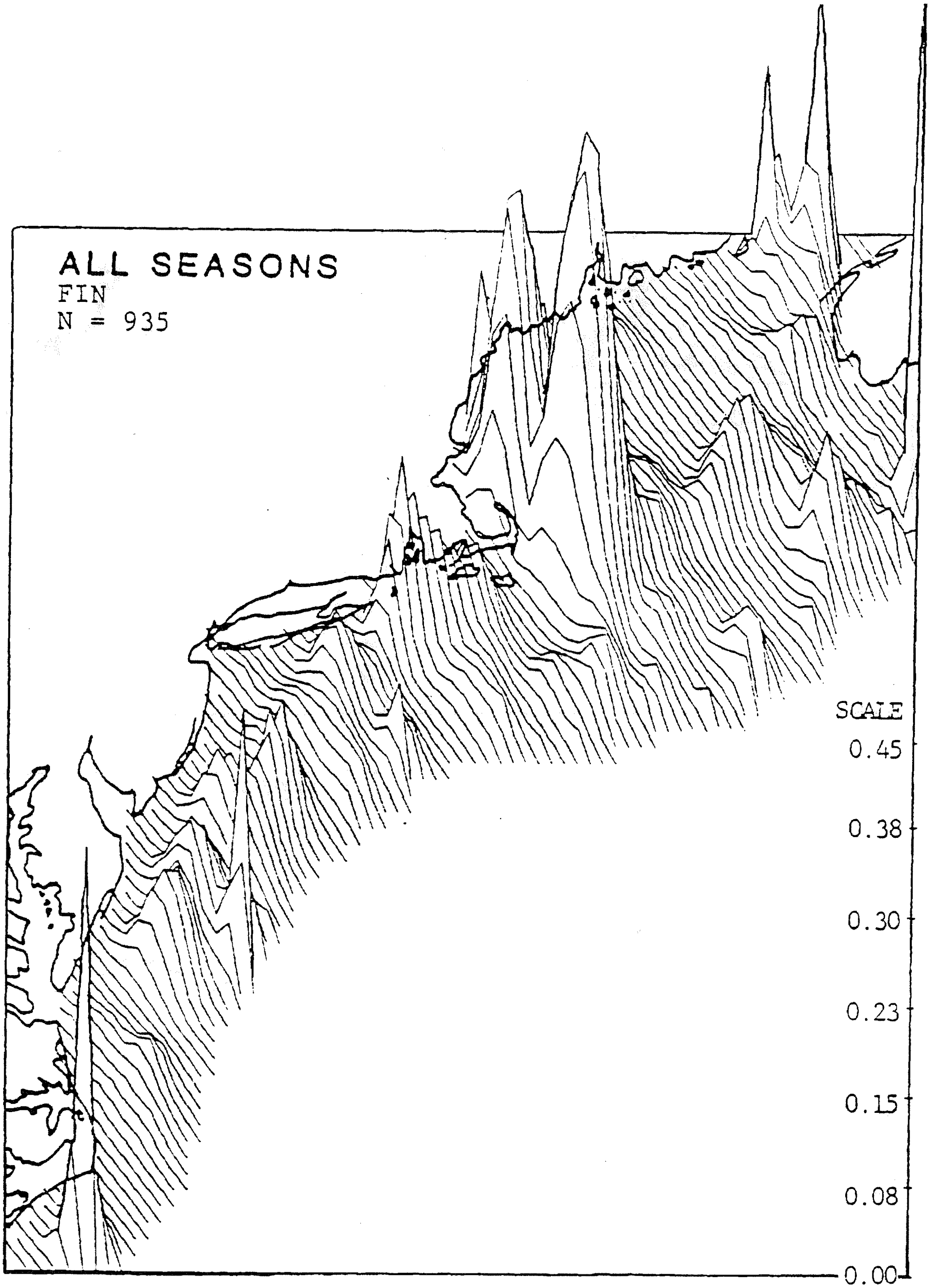

Figure 11b. The relative abundance of B. physalus for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

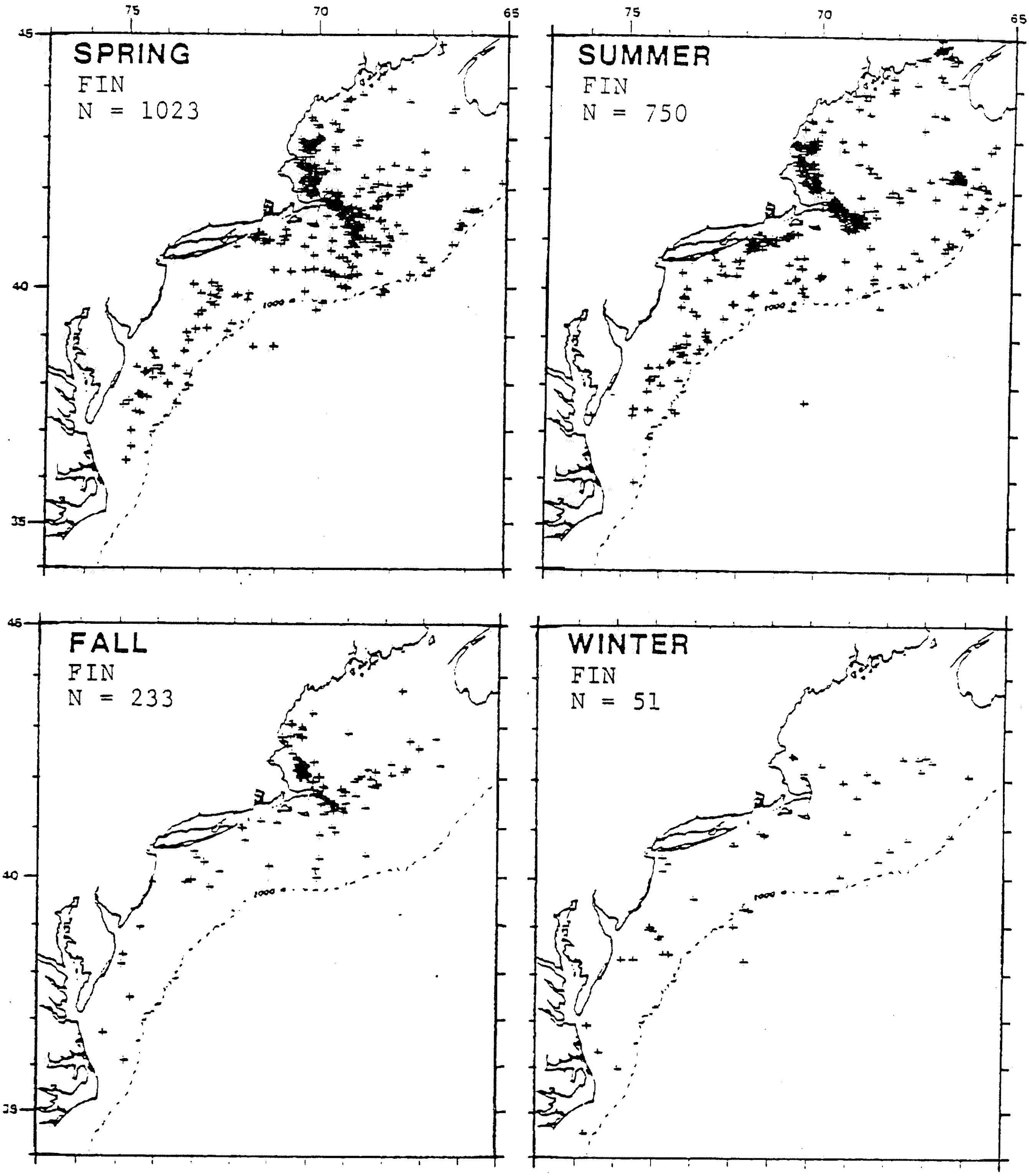

Figure 11c. The sighting distribution of B. physalus by season.

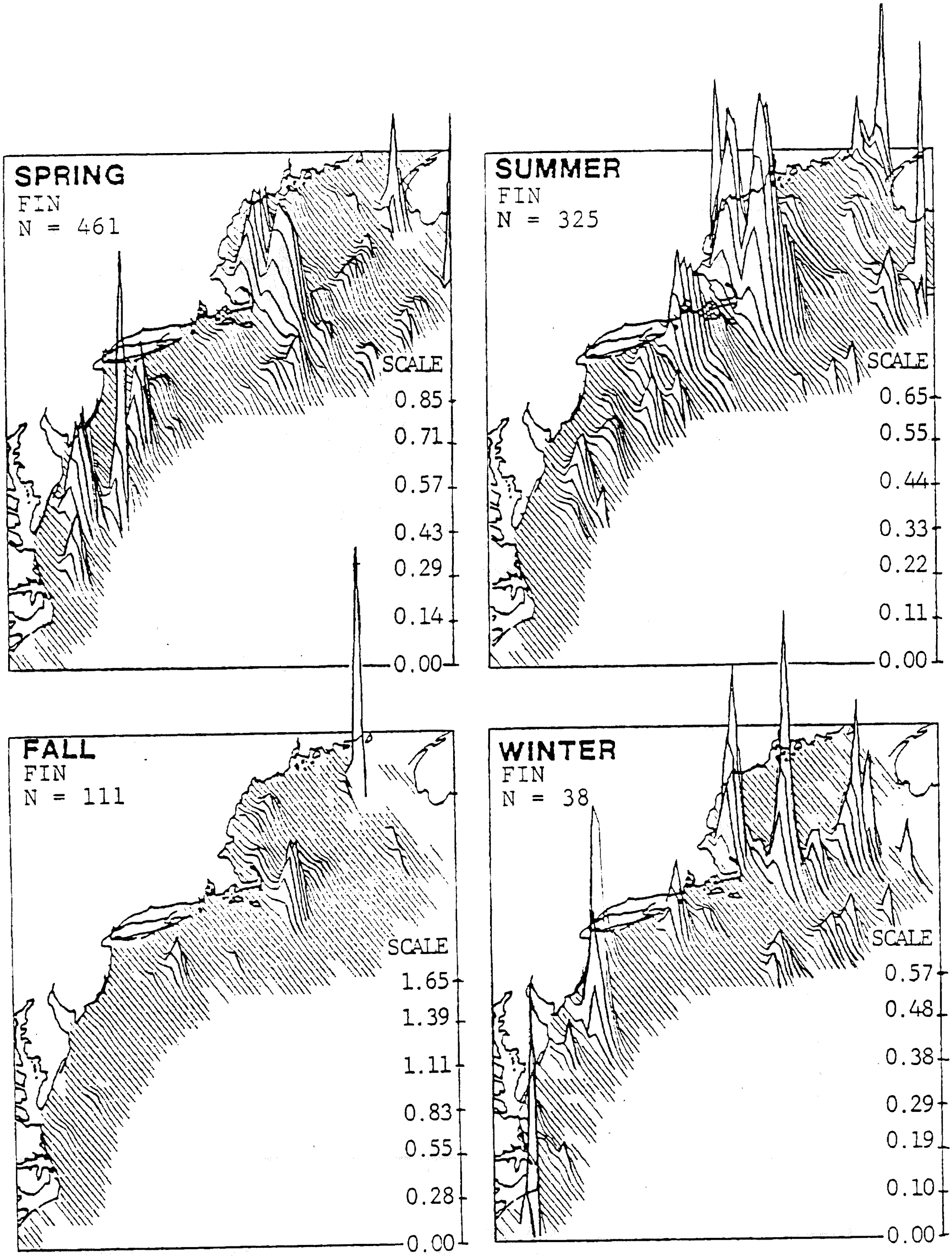

Figure 11d. The relative abundance of B. physalus by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

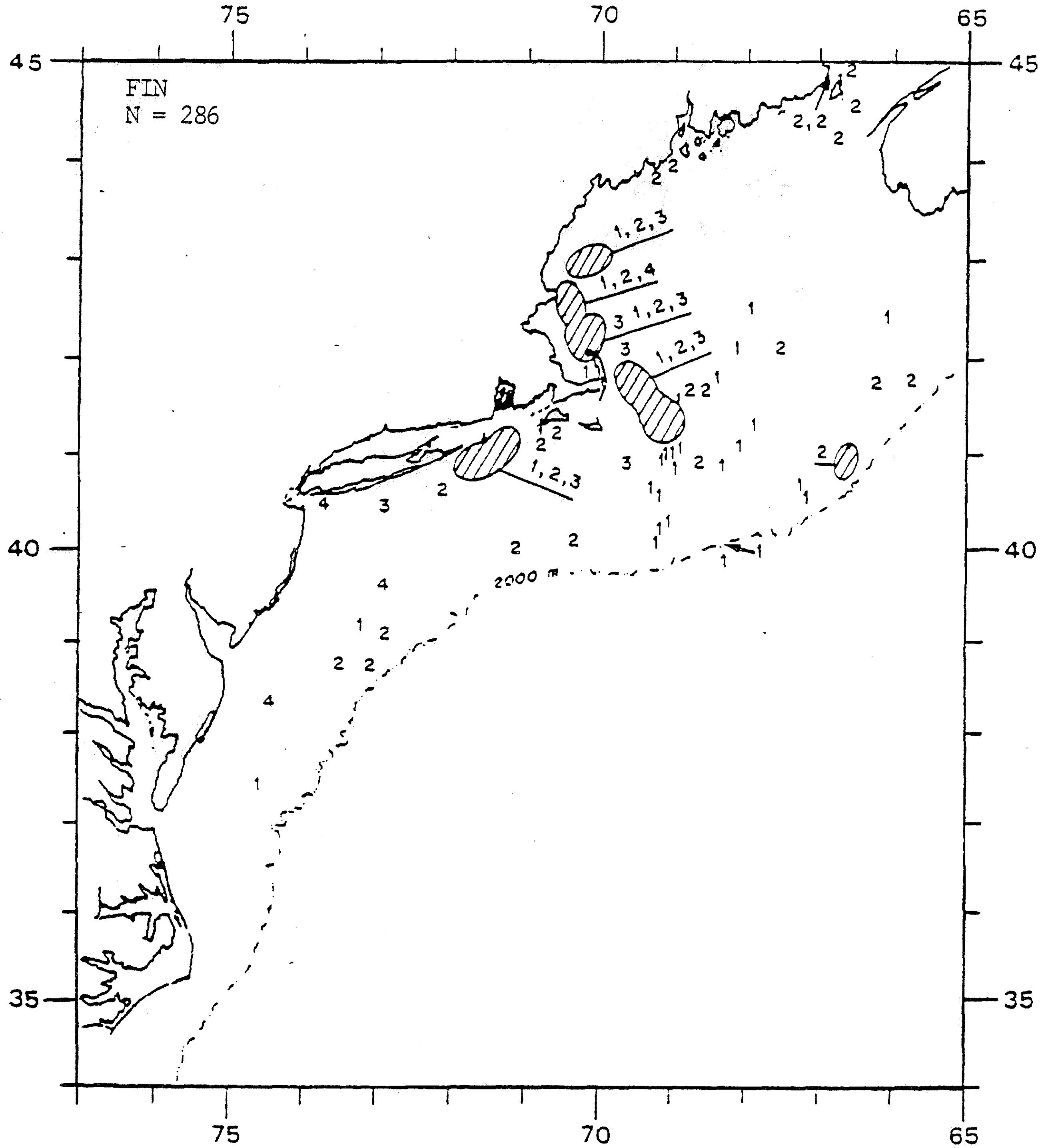

Figure 11e. Sightings of feeding or apparent feeding of B. physalus. Single and widely separated observations are denoted by a number indicating the season in which the sighting occurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations were concentrated in an area, the area has been enclosed by a lined region and the seasons of included observations are shown on the adjoining line.

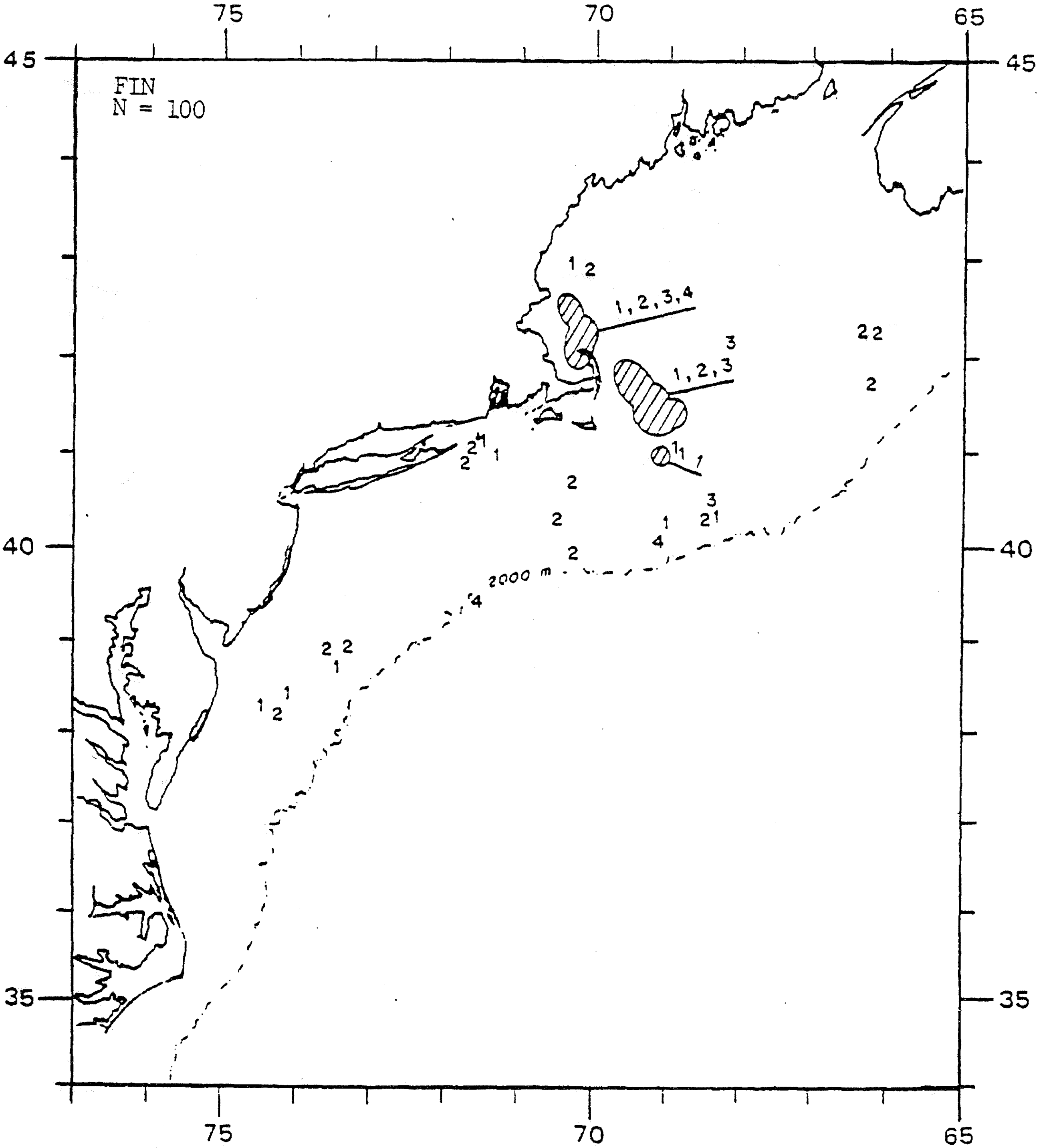

Figure 11f. Sightings of calves or juveniles of B. physalus. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

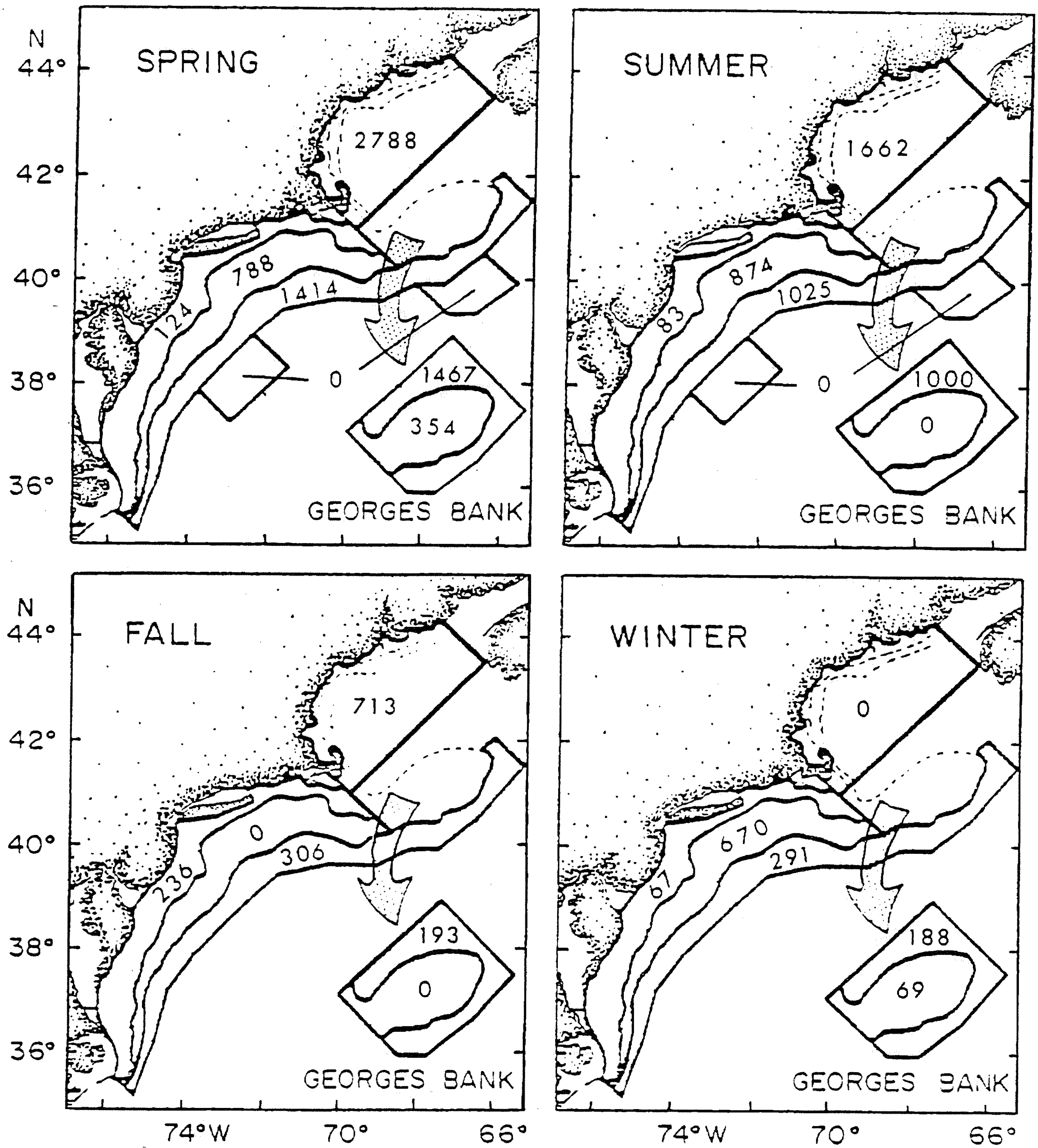

Figure 11g. Estimates of the number of individuals of B. physalus by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 9. Average density (individuals/km²), variance of the density estimated number, and 95% confidence interval by defined region and season for *Balaenoptera physalus*, corrected for diving behavior.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	3.87E-02	2.31E-02	9.89E-03	0.00E+00
	5.88E-03	4.89E-03	3.18E-03	0.00E+00
	2788	1662	713	0
	± 2335	± 2294	± 2251	± 0
GEORGES BANK	2.47E-02	1.27E-02	2.99E-03	2.74E-03
	9.00E-03	4.21E-03	3.51E-04	1.86E-04
	1707	874	206	189
	± 2169	± 1703	± 994	± 398
<50 FATHOMS	1.09E-02	0.00E+00	0.00E+00	2.15E-03
	1.68E-03	0.00E+00	0.00E+00	1.63E-04
	354	0	0	69
	± 682	± 0	± 0	± 295
>50 FATHOMS	4.00E-02	2.73E-02	5.27E-03	5.12E-03
	1.71E-02	9.06E-03	6.19E-04	3.31E-04
	1467	1000	193	188
	± 2386	± 1934	± 1133	± 449
LEASE SALE 52	7.59E-03	1.68E-02	0.00E+00	3.73E-03
	1.17E-03	1.86E-03	0.00E+00	2.78E-04
	212	468	0	104
	± 491	± 727	± 0	± 257
MID-ATLANTIC	9.65E-03	1.23E-02	3.21E-03	7.02E-03
	1.06E-03	1.31E-03	3.18E-04	6.68E-04
	1325	1682	440	964
	± 1076	± 1353	± 731	± 898
NEAR SHORE	3.04E-03	2.02E-03	5.78E-03	1.65E-03
	4.08E-04	2.16E-04	6.09E-04	1.59E-04
	124	83	236	67
	± 356	± 308	± 557	± 234
MID-SHELF	1.51E-02	1.67E-02	0.00E+00	1.28E-02
	1.53E-03	1.58E-03	0.00E+00	1.28E-03
	788	874	0	670
	± 886	± 1071	± 0	± 853
NEW YORK BIGHT	5.80E-03	1.09E-02	4.00E-03	1.02E-02
	4.24E-04	1.21E-03	4.34E-04	1.35E-03
	360	673	248	635
	± 527	± 958	± 664	± 1098
SHELF EDGE	2.28E-02	1.65E-02	4.93E-03	4.68E-03
	9.06E-03	1.99E-03	4.44E-04	3.97E-04
	1414	1025	306	291
	± 2292	± 1143	± 790	± 535
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	5423	4057	1287	1254
	± 3141	± 2876	± 2044	± 1055

*Study area OCS does not include the slope water regions.

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Balaenoptera borealis - Sei whale - Endangered Species

INTRODUCTION

1981 Data. The 3 sightings of sei whales in July in the area immediately south of Montauk Point and Block Island (2 "sure" identifications, 1 "probable") extend the described range of sei whales in the study area about 100 n. miles west of that given in previous CETAP reports. Beyond this, the 1981 data were consistent with the results of CETAP studies in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. *B. borealis* was the sixth most commonly sighted large whale in the study area. The 67 sightings of 204 individuals accounted for 2% of the large whale sightings and 2% of the baleen whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 3.0 (the largest of the baleen species), with a mode of 1, and a range from 1 to 40. This small group size was characteristic of all baleen species, and for the most part, large whales.

SPATIAL AND TEMPORAL DISTRIBUTION

General Distribution. The sei whale has a predominantly spring and summer distribution in the northern part of the study area (Figures 12a-d). The period of greatest abundance is in spring, with the sightings largely concentrated in an area west of Georges Bank and north of Hydrographer Canyon, along the southern margin of Georges Bank, and off the southeast corner of Georges Bank at the seaward entrance to the Northeast Channel. Summer sightings are fewer in number and more widely scattered. The southern and eastern sections of Georges Bank remain as important areas, although the relative abundance is about 1/8 of springtime levels. In fall and winter the species is almost completely absent from the study area. The single fall sighting of 1 individual on 15 October 1980 near the Northeast Peak of Georges Bank was assigned an I.D. reliability of "unsure". Two sightings of 1 and 4 individuals in the same general area on 20 February 1980 were assigned I.D. reliabilities of "sure". Therefore, for the fall and winter months, from October to late February, the species does not regularly occur in the study area. However, while Katona et al. (1978) concluded that the species generally only occurs occasionally in the area, present data indicate that for about half the year, sei whales are a common and regular component of the cetacean fauna in the more northerly sections of the study area.

The two southerly sightings (July 1980, east of the Delmarva Peninsula, and June 1980, east of N.C.) were both "probable" identifications. Therefore, the occurrence of sei whales south of 40°N requires future information.

Based on Mitchell and Chapman (1977) the sei whales in the study area are part of the hypothetical Nova Scotia stock which has its most common occurrence from southern New England waters to south of Newfoundland.

Feeding. Sightings of surface feeding sei whales, like sei whale sightings in general, were confined primarily to shelf edges, particularly at the southern edge of the Great South Channel (Fig. 12e). There were also scattered feeding sightings near the Northeast Peak of Georges Bank, coincident with the various sei whale sightings in the Northeast Channel and nearby Gulf of Maine waters. Surface feeding sightings comprised approximately 15% of all sei whale sightings. All of the feeding sightings were in spring and summer, with no differences between months.

Sei whales are primarily copepod feeders (Mitchell, 1976; Nemoto, 1970). They have been classified as "skimmers", in light of their feeding behavior, which is similar to that of right whales (Nemoto, 1970). Recent studies of zooplankton distributions indicate that _Calanus finmarchicus_ is found primarily in stratified waters surrounding Georges Bank, while _Pseudocalanus_ spp. are distributed primarily in the well-mixed waters on the Bank itself. Perhaps the distribution of sei whales along the edges of Georges Bank and the Great South Channel is a reflection of the copepod distribution.

Fifty percent of the surface feeding sightings of sei whales are either within proposed Lease Area 52 or directly to the west of it. Furthermore, there were numerous general sightings of sei whales within Area 42 and Proposed Area 52. Given the aforementioned correlation of _Calanus finmarchicus_ with the outer edges of Georges Bank, and the preference of sei whales for copepods such as _C. finmarchicus_, it appears likely that Area 42 and Proposed Area 52 are coincident with important feeding grounds for sei whales in the study area.

Calves and Juveniles. During the 3 year survey period, 3 sei whale calf or juvenile sightings were reported. Figure 12f shows their locations. During May 1980, a calf sighting was reported from the northeastern edge of Georges Bank (1000m). Another sighting was found along the western edge of the Great South Channel (100m) during June, 1979. The third sighting was reported from the southeastern edge of Georges Bank (1000m) during July, 1979. No calves were sighted during the fall or winter seasons.

Although parturition is believed to occur between January and March, the location of sei whale calving grounds is unknown (Katona et al., 1978). The paucity of calf sightings parallels the relatively small number of sei adult sightings. Calves were found among adult groups ranging in size from 2 to 8 animals.

No calves were found within BLM Lease Sale Areas 40, 42, 49, or 59, or within Proposed Lease Sale Area 52.

Areas. No sightings of sei whales have been reported for Mid-Atlantic areas 40, 49, or 59. In the North Atlantic areas, the species does occur in spring and summer in the southern section of 42 and eastern 2/3 of Proposed Lease Sale 52. The area between Hydrographer Canyon and the Great South Channel, and along the southern margin of Georges Bank, appear to be areas of common occurrence for the species (predominantly in the spring). This area falls within the boundaries of Proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 10 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 12g. The peak average abundance estimate of sei whales for the Study Area (280 +/- 313) occurred during the spring. Correspondingly, the peak average abundance estimate of this species in waters of Georges Bank greater than 50 fathoms in depth (253 +/- 321) also occurred during the spring. The maximum point estimate of abundance of this species (469 +/598) occurred in sampling block Q, stratum z, during May 1981. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. These estimates are undoubtedly negatively biased due to animal diving behavior and other factors. Assuming that sei whales spend proportionally the same amount of time at the surface relative to below as do fin whales then the estimated number of this species occurring in the waters of the US OCS is 2273. This number may represent the entire estimated stock of sei whales in the Nova Scotian management area (1398-2248 individuals, Mitchell and Chapman 1977).

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature for sei whale sightings was 11.2°C, the third coldest for all baleen whales; the mode was 13.0 with a range from 5.0 to 19.8°C. Ninety percent of all sightings were found in cold to moderately warm water (5.8 to 18.2°C).

Depth (m). The average depth for sei whale sightings was 506m, the deepest of all baleen species; the mode was 88 with a range from 31 to 3579m. Ninety percent of these sightings were found in a relatively wide depth range (49 to 2124m). The greatest concentration of sei whales was found along the shelf edge, which may explain this wide depth range.

BEHAVIOR

Associations. Cetacean multispecies aggregations were recorded on 9 of 67 sightings (13%) of sei whales. Although _B.borealis_ was observed in proximity to at least 4 species of large whale and 3 species of small whale, associations with _E.glacialis_ and _B.physalus_ were the most numerous, with each occurring on 3 occasions. Less frequent occurrences with other species are noted in Table 30. Aggregations involving sei whales often occurred within areas of feeding activity; on only two occasions were more than two species present.

Migration and Movement. The highly seasonal occurrence of the sei whale in the study area is strongly suggestive of a movement into the northern sections in spring and a departure from the area in the fall. A number of early spring sightings and a few fall sightings south of Georges Bank and seaward of the shelf edge (Mitchell and Chapman, 1977) may represent a seasonal offshore habitat and/or an offshore migration route along north-south lines.

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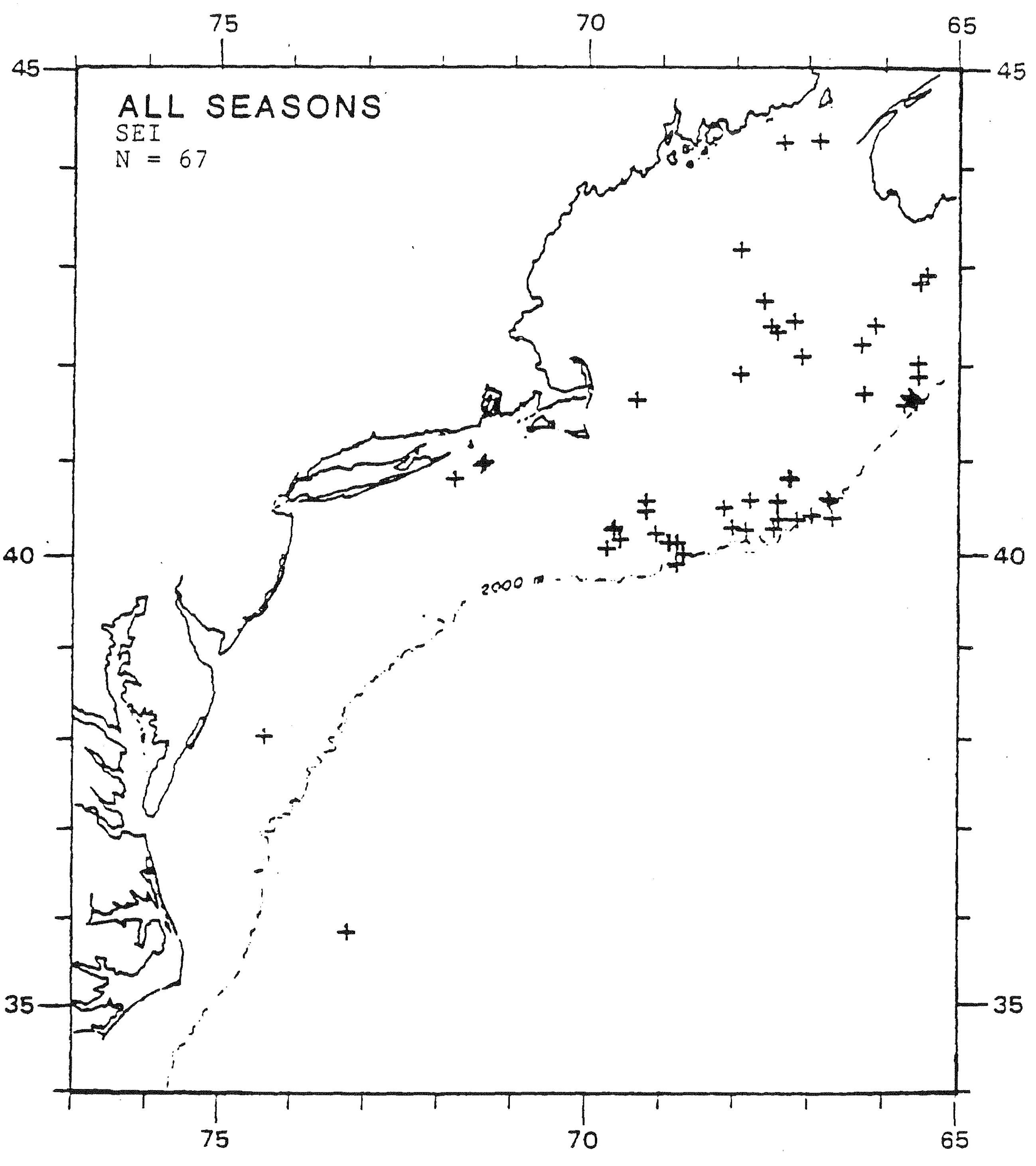

Figure 12a. All sightings of the sei whale, Balaenoptera borealis, for the 39 month period -- 1 November 1978 through 28 January 1982.

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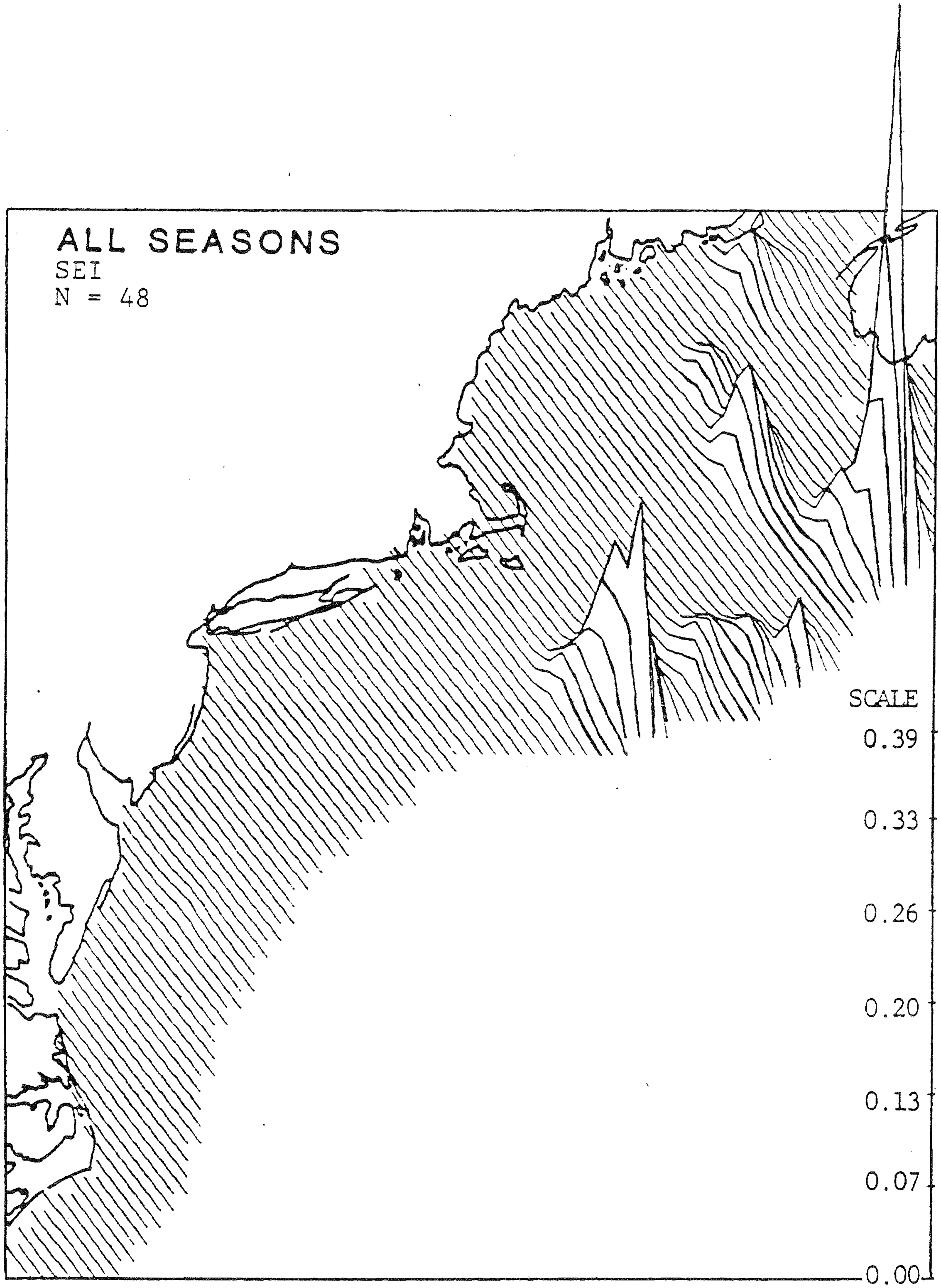

Figure 12b. The relative abundance of B. borealis for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

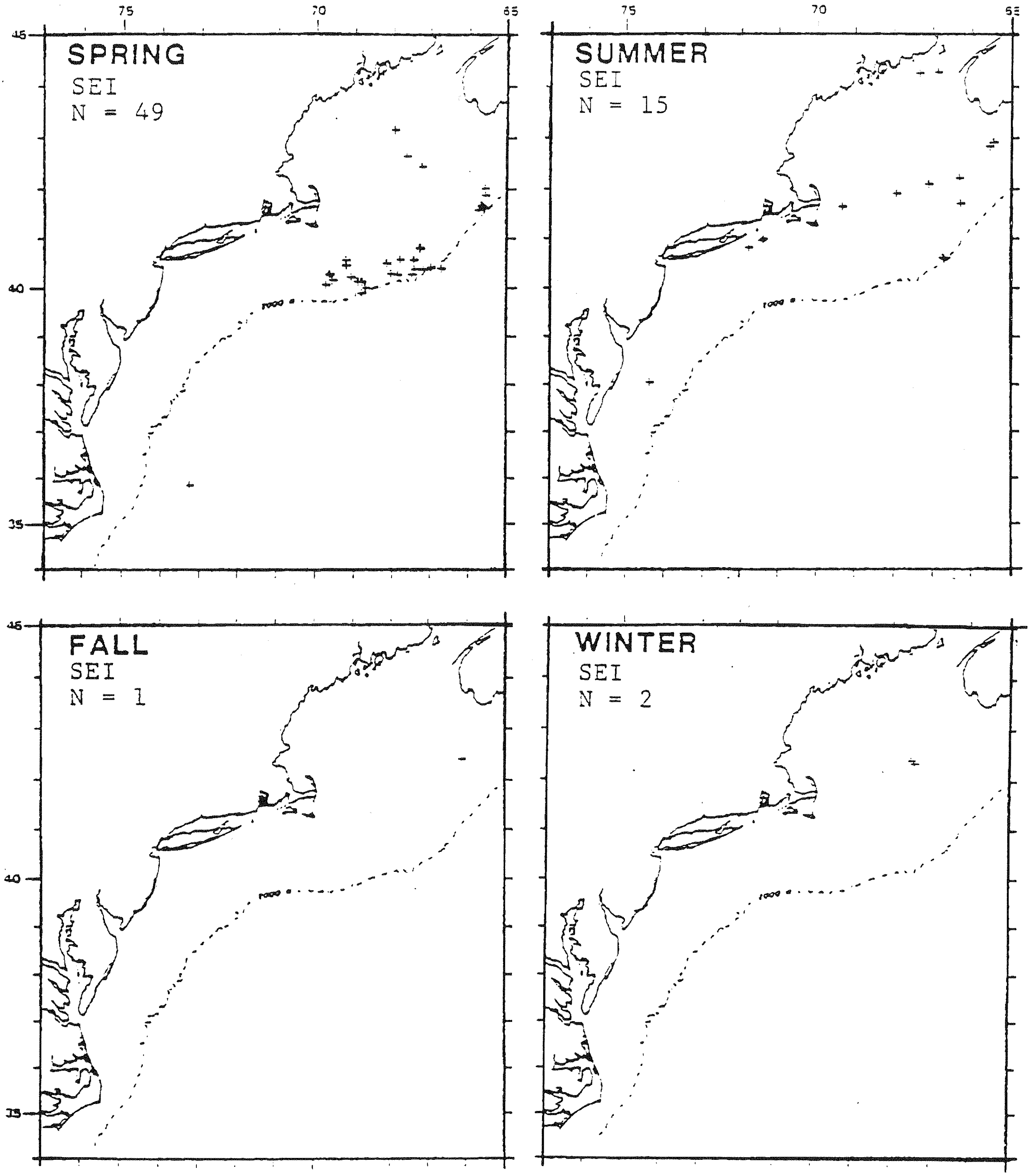

Figure 12c. The sighting distribution of B. borealis by season.

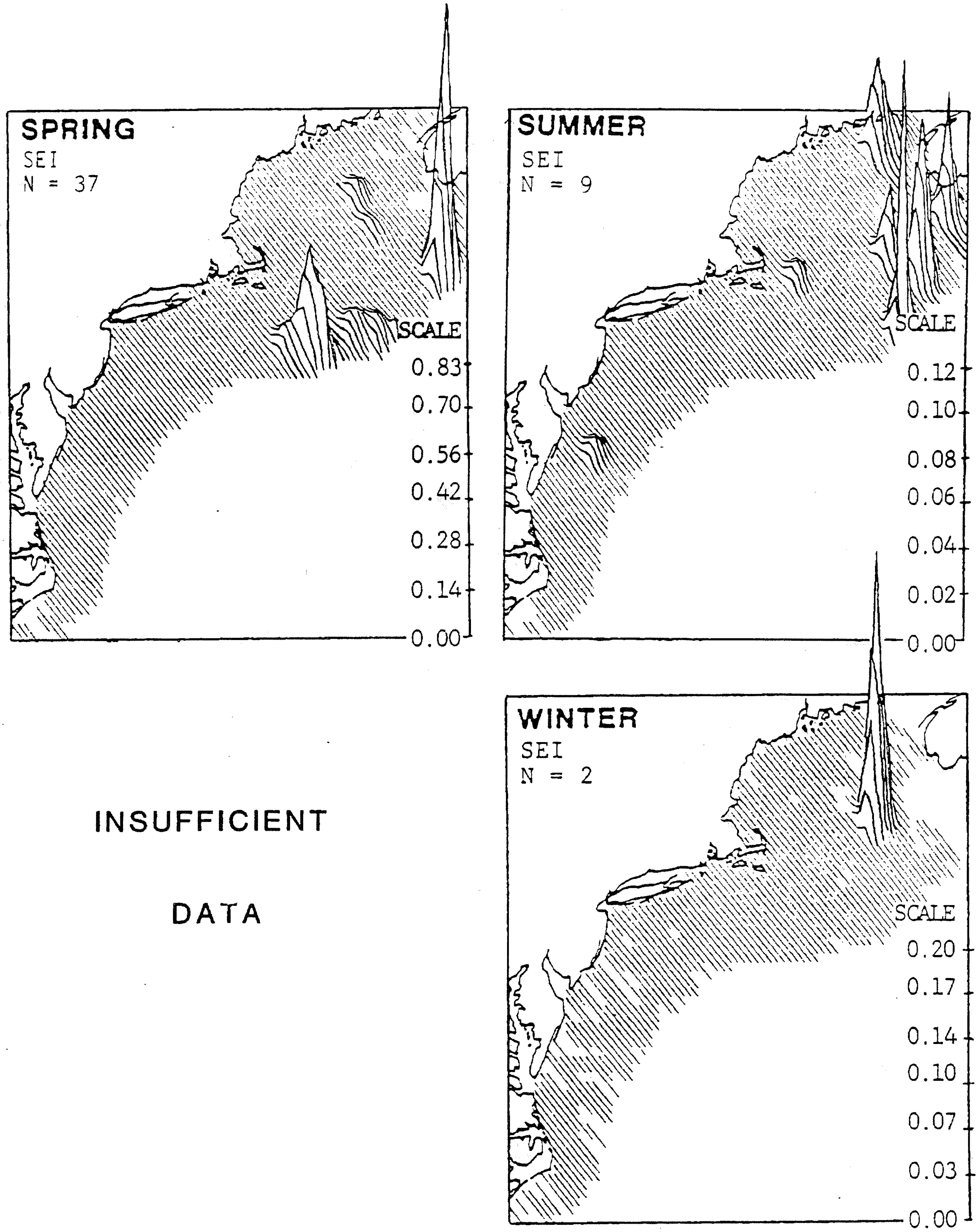

Figure 12d. The relative abundance of *B. borealis* by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

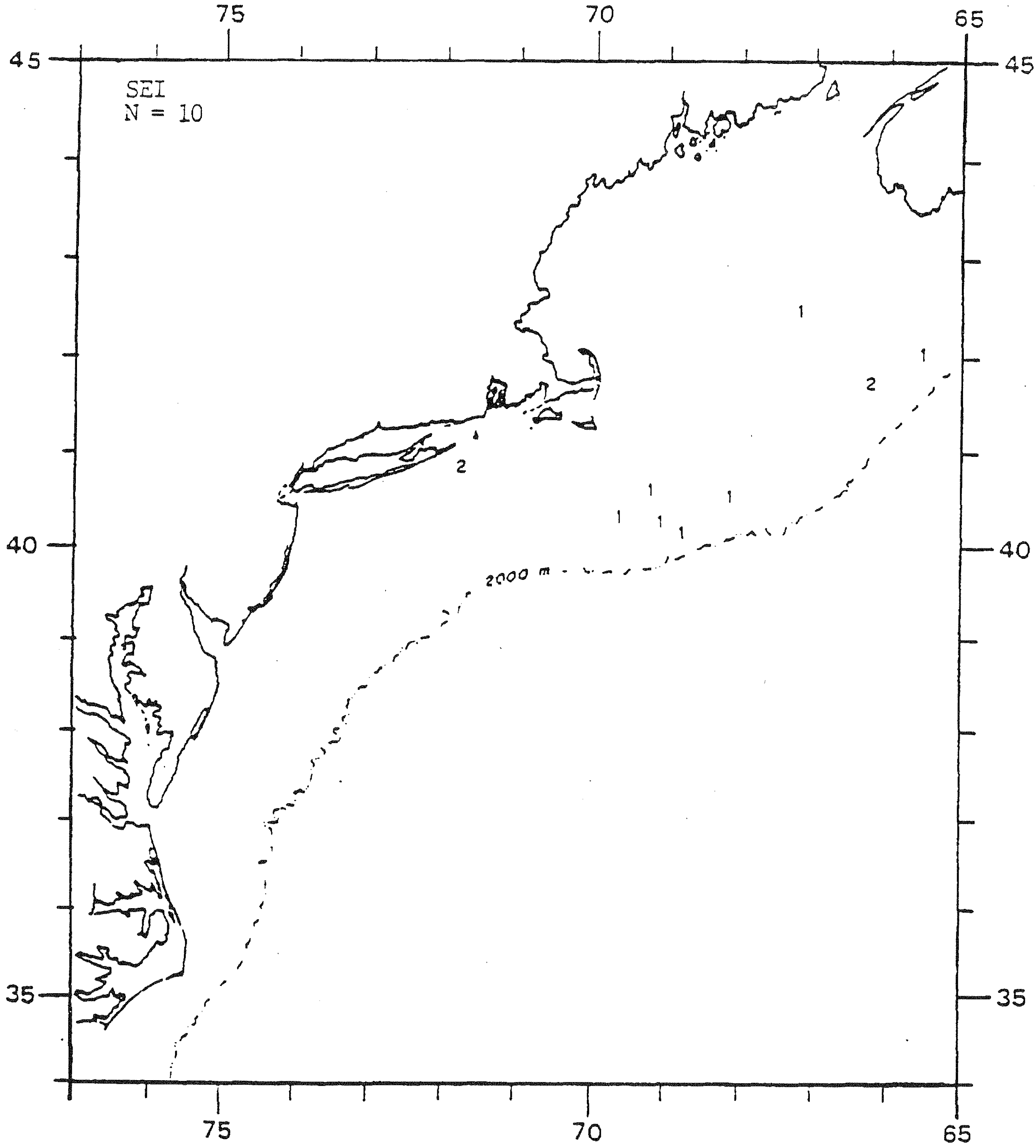

Figure 12e. Locations of sightings of feeding or apparent feeding of B. borealis. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

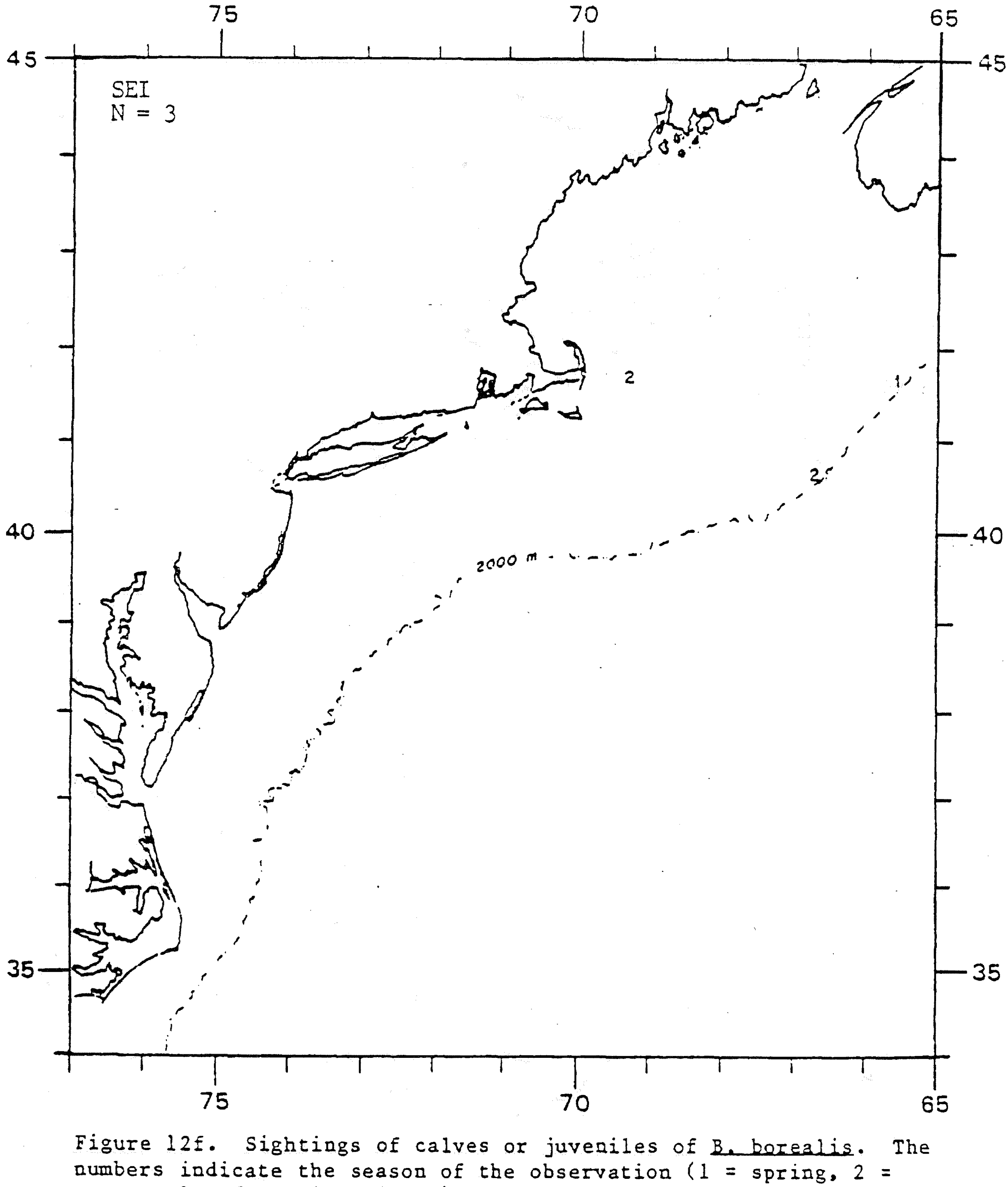

Figure 12f. Sightings of calves or juveniles of <u>B. borealis</u>. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

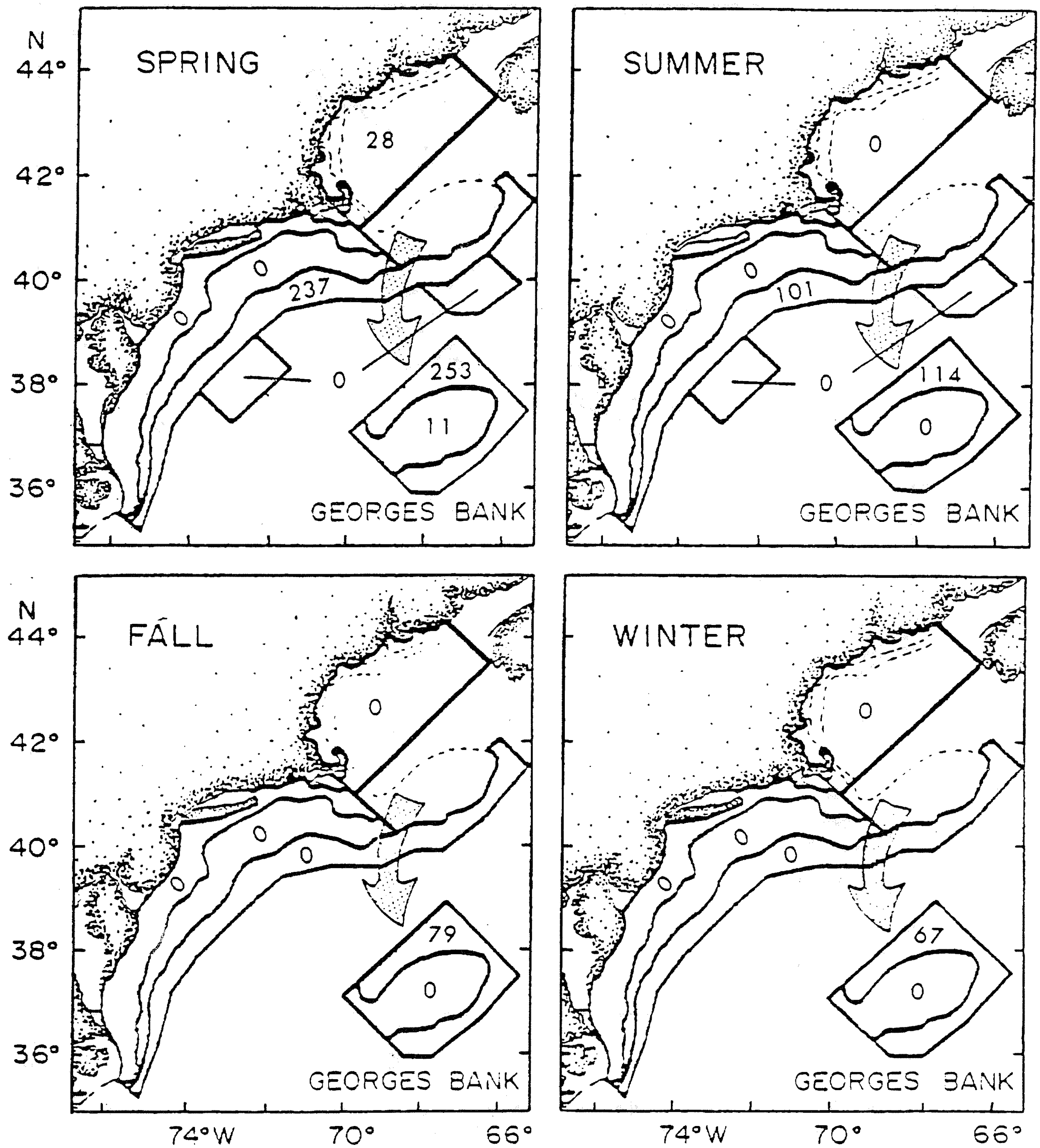

Figure 12g. Estimates of the number of individuals of B. borealis by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 10. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Balaenoptera borealis*.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	3.86E-04 5.05E-06 28 ± 68	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
GEORGES BANK	3.45E-03 1.49E-04 238 ± 279	1.45E-03 1.16E-04 100 ± 282	1.22E-03 1.48E-05 84 ± 204	7.05E-04 1.50E-05 49 ± 113
<50 FATHOMS	3.32E-04 3.93E-06 11 ± 33	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
>50 FATHOMS	6.90E-03 3.09E-04 253 ± 321	3.12E-03 2.49E-04 114 ± 321	2.16E-03 2.61E-05 79 ± 233	1.84E-03 3.90E-05 67 ± 154
LEASE SALE 52	3.67E-03 1.68E-04 102 ± 186	3.11E-03 2.49E-04 87 ± 266	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-ATLANTIC	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEAR SHORE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-SHELF	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEW YORK BIGHT	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
SHELF EDGE	3.81E-03 1.85E-04 237 ± 327	1.63E-03 1.30E-04 101 ± 293	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
CONTINENTAL SLOPE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	. . . ± .	. . . ± .
STUDY AREA OCS*	280 ± 313	110 ± 303	44 ± 92	45 ± 97

*Study area OCS does not include the slope water regions.

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Balaenoptera acutorostrata - Minke whale

INTRODUCTION

1981 Data. The 1981 data were consistent with the results previously reported for 1979 and 1980. The sections below describe the cumulative results for all years.

Number of Sightings. B. acutorostrata was the third most commonly sighted large whale in the study area. The 518 sightings of 782 individuals accounted for 12% of the large whale sightings and 13% of the baleen whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 1.5, the second lowest of the baleen whales. The mode was 1, with a range from 1 to 15. This small group size was typical of all baleen whales, and most large whales.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. There is a strong seasonal component to the istribution of B. acutorostrata in the study area (Figures 13a-d). Spring and summer are times of relatively widespread and common occurrence. In fall, the number of individuals and the areas they occupy are reduced. In winter the species is largely absent from the study area. Like other baleen whales, the minke whale generally occupies the shelf proper, rather than the shelf-edge region.

During the times of greatest numbers and most widespread distribution, in spring and summer, the most important area is described by a large "U". This area extends eastward from Montauk Pt. by Block Island to southeast of Nantucket Shoals, from there northward along western Georges Bank through the Great South Channel area, east of Cape Cod, and across Stellwagen Bank to Cape Ann and Jeffrey's Ledge. This area remains important through the summer, with the expansion of the area of common occurrence northward into the northern Gulf of Maine and the mouth of the Bay of Fundy. In the fall, the population thins and the range is contracted. However, the areas in the western Gulf of Maine and east and southeast of Cape Cod continue to be important habitats. In winter, the infrequent sightings of minke whales occurred in the western Gulf of Maine and southeast of Cape Cod. A feature of the data is that in three years of observations there has only been one minke whale sighting south of Long Island in the fall (1 individual, I.D. "probable", 2 October 1980, shelf edge east of Delmarva peninsula), and no sightings south of Long Island in the winter.

Feeding. In comparison to the total number of minke whale sightings, there were relatively few sightings of surface feeding by minke whales (only 4% of the total). These feeding sightings were scattered throughout the northern half of the study area, virtually all occurring inside the 100 m contour. Surface feeding was observed in the Great South Channel, east of Montauk Point, and along Cape Ann and Jeffreys Ledge (Fig. 13e).

Some 95% of the feeding sightings were in spring and summer, however it is noted that these are the seasons of principle abundance in the study area. There were no discernable latitudinal or geographic differences between spring and summer.

Minke whales are predominantly ichthyophagous in the study area (Gaskin, 1976; Katona et al., 1978), feeding primarily on gadoids and clupeids. Given the recent decline in herring (Sherman et al., 1981), minke whales may have switched to the more abundant sand lance.

The paucity of surface feeding sightings is probably not a reflection of any true lack of feeding in the area, but rather a consequence of the probable sub-surface feeding behavior on the part of the minke whales, and their relatively small size. It is likely that inshore areas throughout the Gulf of Maine (Sergeant, 1963; Gaskin, 1976), the Great South Channel-Jeffreys Ledge corridor, and the southern edge of Georges Bank are all feeding areas for minke whales.

Although there were numerous minke whale sightings within or directly adjacent to all the lease areas, there were no surface feeding sightings within the lease areas. However, several surface feeding observations were made just to the west of Proposed Area 52, as well as in the Great South Channel which is directly to the northwest of Area 42 and Proposed Area 52.

Calves and Juveniles. During the 3 year survey period, only 2 sightings of minke whale calves or juveniles were reported. Their locations are shown in Figure 13f. One sighting was located between the 1000 and 2000 meter isobaths (south of Martha's Vineyard) during April, 1980. The other sighting reported during June, 1979 was located between the 100 and 200 meter isobaths (southeast of Nantucket).

Minke whales are probably born during the winter (Mitchell and Kozicki, 1975). Mead (1975) suggested that the calving grounds may be located in the southern portions of their range. The reason for the limited number of calf sightings, despite a considerable number of adult sightings (518), is difficult to ascertain.

One of these calf sightings was found close to, and the other within, Proposed Lease Sale Area 52. No calves were sighted within Lease Sale Areas 40, 42, 49, or 59.

Areas. The minke whale is only occasionally found, and on a widely scattered basis, in the Mid-Atlantic Lease Sale Areas (40, 49, 59). There is a more common occurrence in the North Atlantic Areas (42, Proposed Area 52), particularly, in the eastern portion of, and in close proximity to the northwestern boundary of, Proposed Lease Sale 52. The extreme southern portion of Proposed 52 contains only one sighting, at the far western end. The area shoreward of the 100 m contour from Block Canyon to western Georges Bank is most likely an important habitat for the minke whale. This region is within or near the northern boundary of Proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 11 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 13g. The peak average abundance estimate of minke whales (320 +/- 150) in the Study Area occurred during spring. The maximum point estimate of abundance (414 +/- 445) was made during the first year's sample in sampling block C during June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 313 (+/- 338) in sampling block C, stratum y, in June 1979. These estimates are undoubtedly negatively biased due to diving behavior and other factors. Assuming that minke whales spend the same proportion of time at the surface as fin whales, then the minimum estimated stock of this species in the waters of the US OCS is 2006 individuals. This number represents only between 2.8-4.0% of the estimated 50,000-70,000 minke whales in the North Atlantic (Nishiwaki, 1972).

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature for minke whale sightings was 12.6°C, the second warmest of all baleen species; the mode was 8.0 with a range from 5.0 to 23.0°C. Ninety percent of all sightings fell within a wide temperature range (6.2 to 20.0°C). This corresponds with the wide latitudinal range of minke whale sightings from Cape Hatteras to the Bay of Fundy.

Depth (m). The average depth for minke whale sightings was 133m, the second most shallow distribution of all baleen species. The mode was 64, with a range from 3 to 3027m. Ninety percent of these sightings were made in depths ranging from 18 to 606m. This corresponds with the distribution of minke whales in inshore waters and along the continental shelf.

BEHAVIOR

Associations. Minke whales were associated with another cetacean species in 23 percent of the sightings. Of the four large whale species and seven small whale species involved, *B.physalus* and *M.novaeangliae* accounted for 72% of the total *B.acutorostrata* associations. *P.phocoena* and *L.acutus*, each representing 8% of the total associations, were the most frequently involved small whale species. Although minke whales have been observed in aggregations comprising as many as 5 species, 62 percent involved only one additional species. Consistent with previous observations, these occurrences typically involved either fin or humpback whales, and only occasionally involved other cetacean species.

Migration and Movement. The strong seasonal differences in abundance and distribution clearly suggest a movement into and out of the study area. Within the study area, some portions are occupied over much of the year, while other portions appear to be occupied on a more transitory basis.

Based on the CETAP data, a seasonal clockwise migration is hypothesized. In early spring minke whales move into the area from offshore and/or southern waters. Over the course of the summer, there is a general northward shift. The near absence of fall and winter sightings in the Mid-Atlantic Bight suggests that the fall migration out of the area passes in deeper waters beyond the shelf edge. The few winter sightings represent either late departures or early arrivals in the migration pattern. Alternatively, some individuals may remain in the area through the winter.

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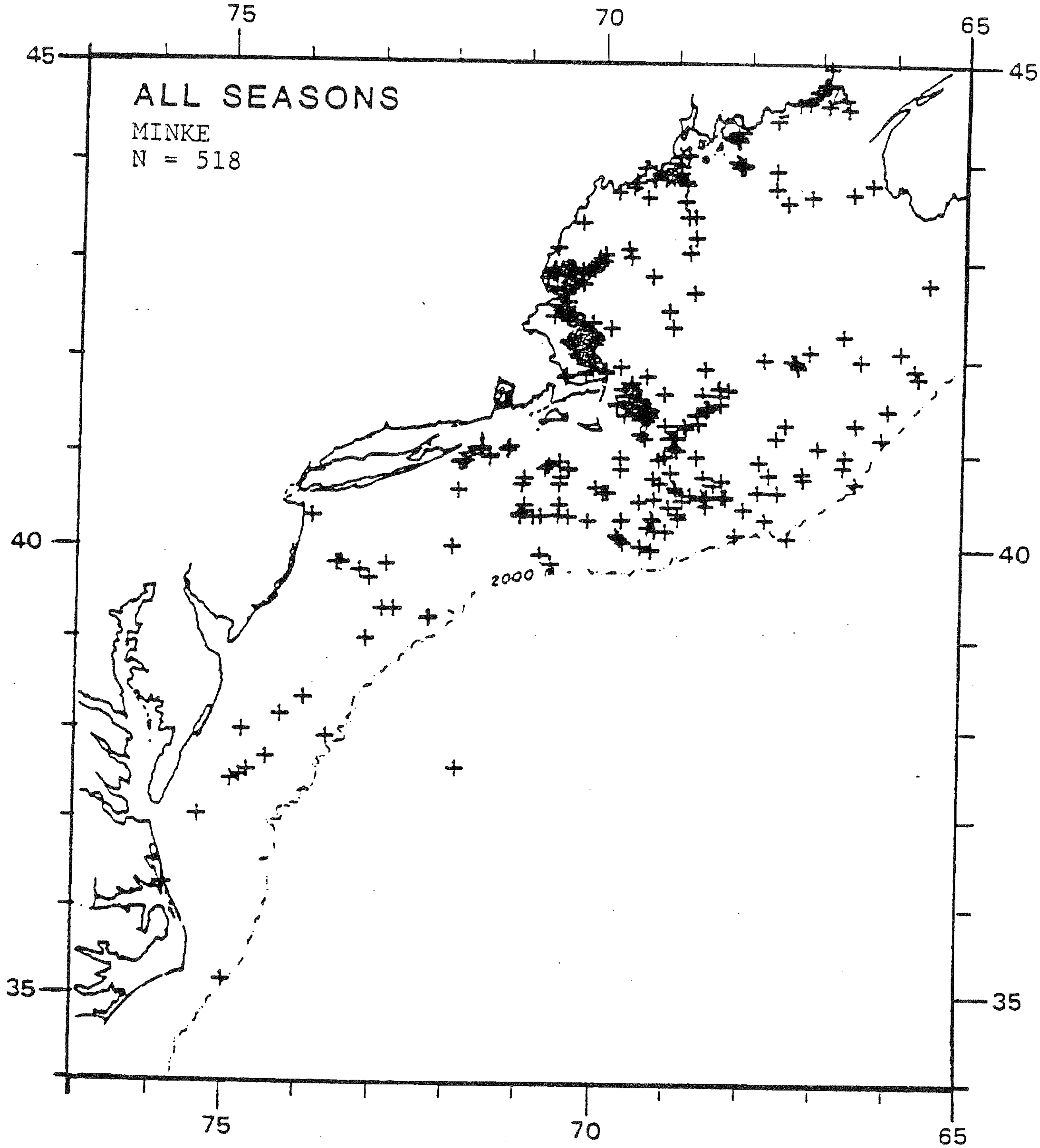

Figure 13a. All sightings of the minke whale, Balaenoptera acutorostrata, for the 39 month period -- 1 November 1978 through 28 January 1982.

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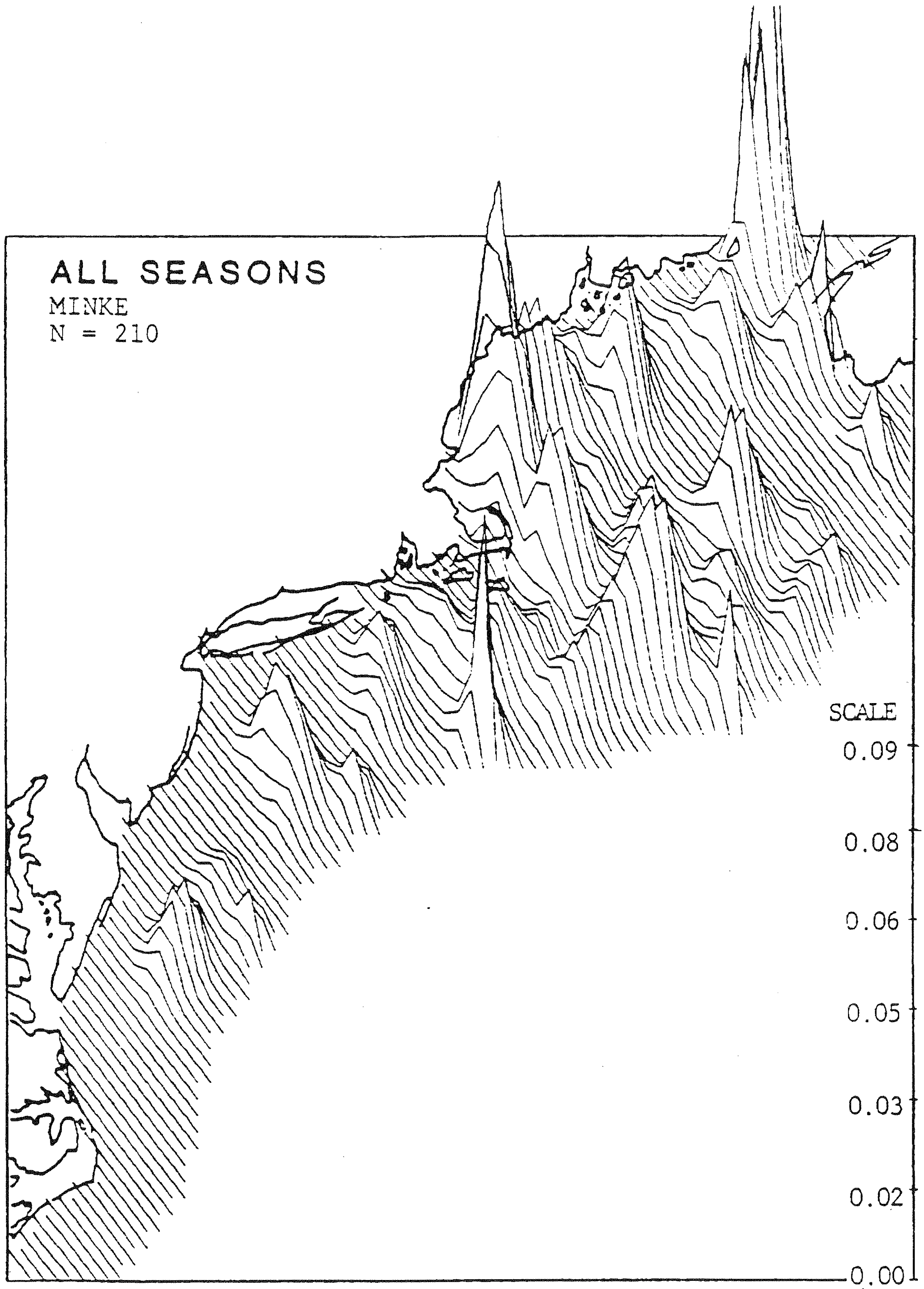

Figure 13b. The relative abundance of B. acutorostrata for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

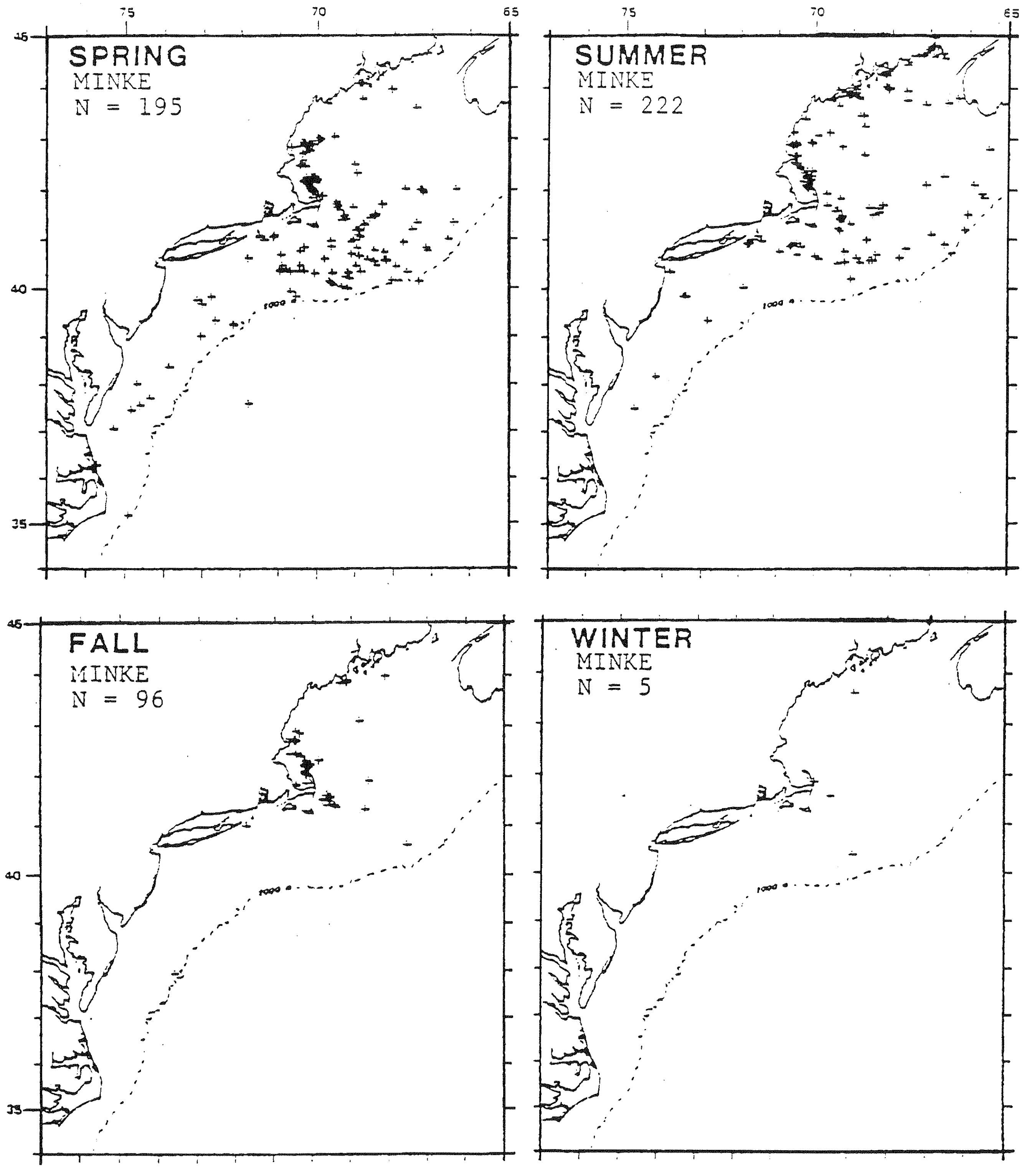

Figure 13c. The sighting distribution of B. acutorostrata by season.

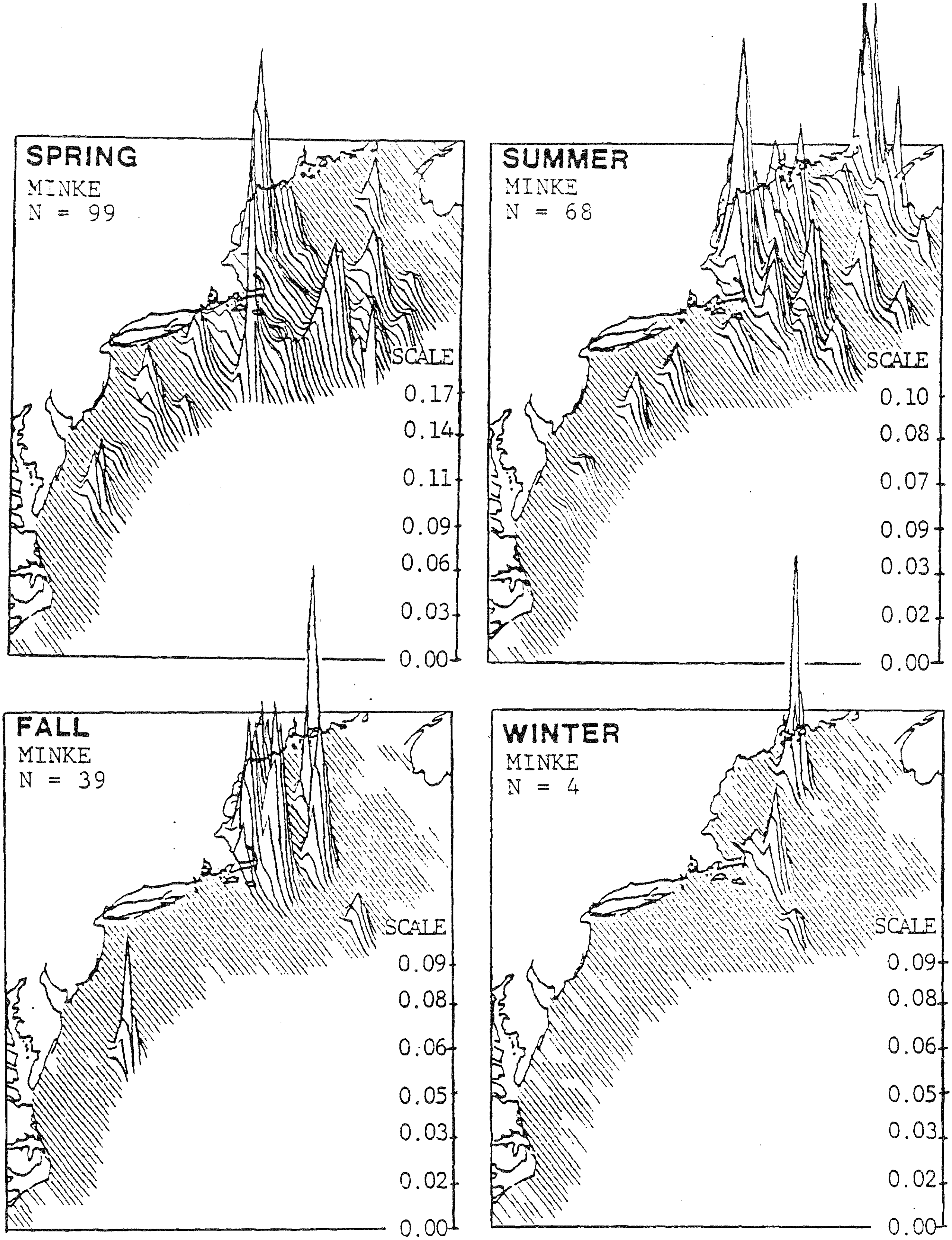

Figure 13d. The relative abundance of B. acutorostrata by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

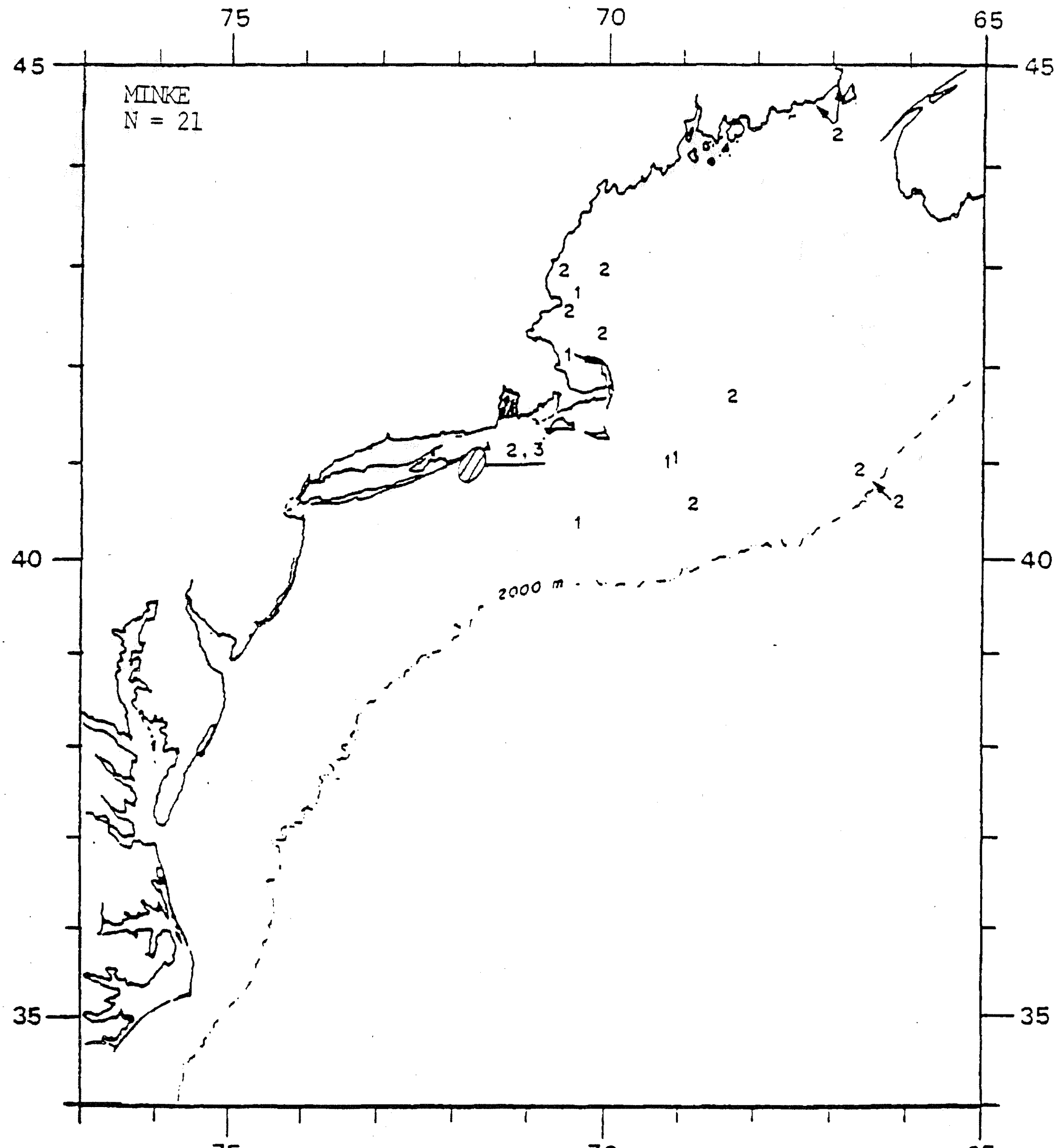

Figure 13e. Sightings of feeding or apparent feeding of B. acutorostrata. Single and widely separated observations are denoted by a number indicating the season in which the sighting occurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations were concentrated in an area, the area has been enclosed by a lined region and the seasons of included observations are shown on the adjoining line.

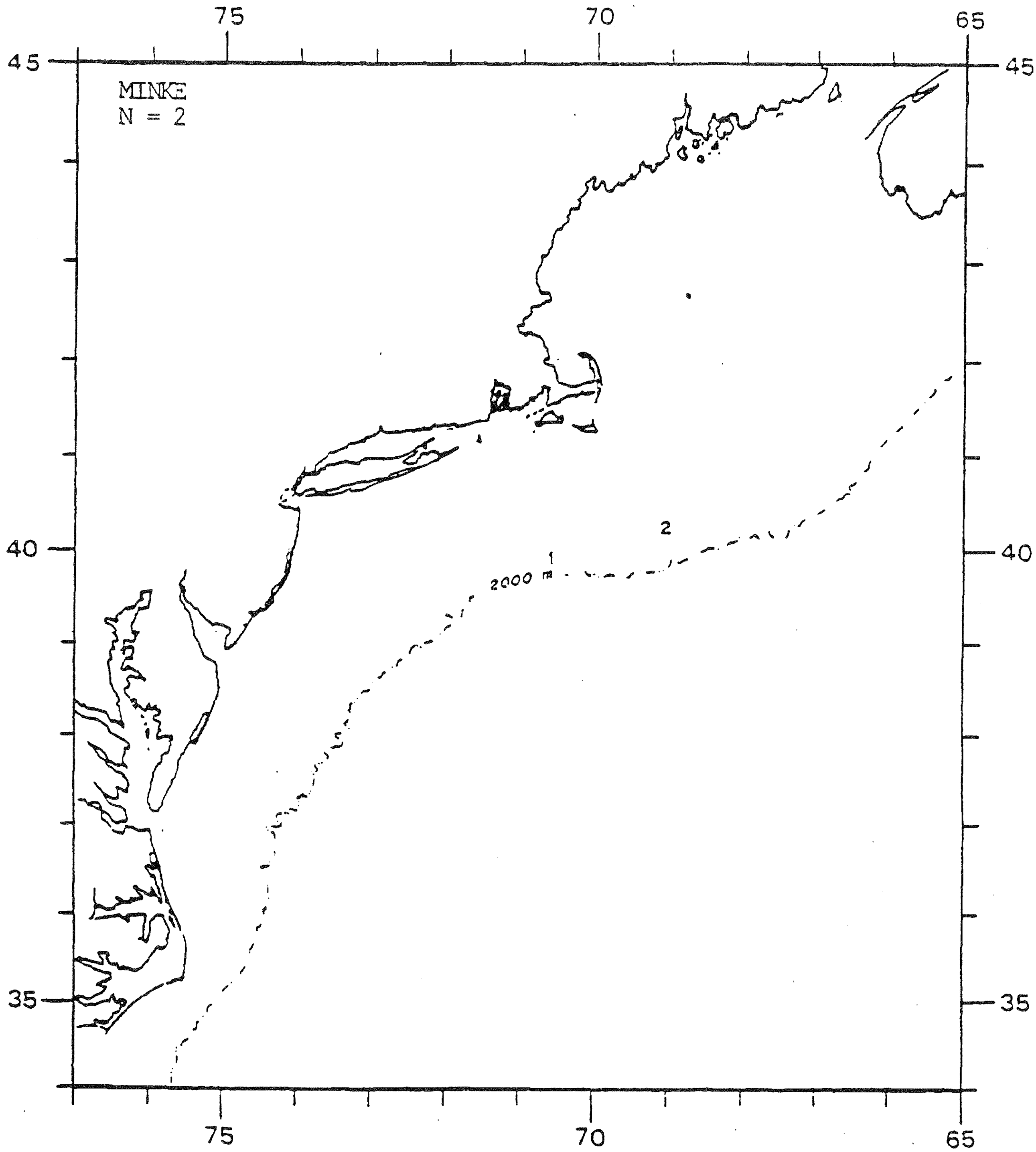

Figure 13f. Sightings of calves or juveniles of B. acutorostrata. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

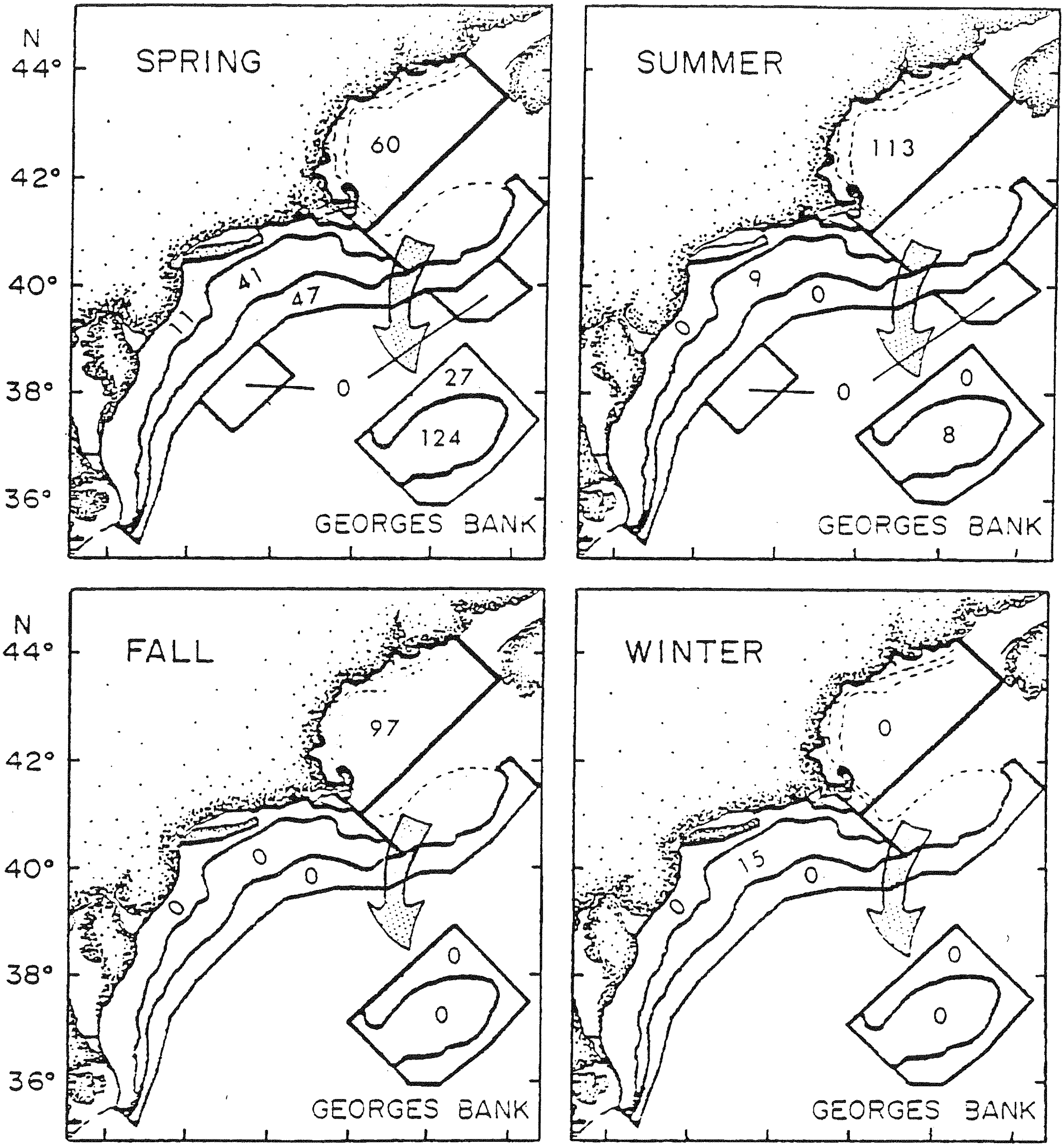

Figure 13g. Estimates of the number of individuals of B. acutorostrata by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 11. Average density (individuals/km^2), variance of the density, estimated number, and 95% confidence interval by defined region and season for <u>Balaenoptera acutorostrata</u>.

REGION	SEASON: SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	8.35E-04	1.57E-03	1.35E-03	0.00E+00
	2.69E-06	7.54E-06	1.43E-05	0.00E+00
	60	113	97	0
	± 50	± 90	± 151	± 0
GEORGES BANK	2.36E-03	1.38E-04	0.00E+00	0.00E+00
	2.39E-05	7.32E-07	0.00E+00	0.00E+00
	163	10	0	0
	± 112	± 22	± 0	± 0
<50 FATHOMS	3.82E-03	2.57E-04	0.00E+00	0.00E+00
	4.02E-05	1.37E-06	0.00E+00	0.00E+00
	124	8	0	0
	± 105	± 22	± 0	± 0
>50 FATHOMS	7.45E-04	0.00E+00	0.00E+00	0.00E+00
	5.76E-06	0.00E+00	0.00E+00	0.00E+00
	27	0	0	0
	± 44	± 0	± 0	± 0
LEASE SALE 52	2.51E-03	0.00E+00	0.00E+00	0.00E+00
	2.56E-05	0.00E+00	0.00E+00	0.00E+00
	70	0	0	0
	± 73	± 0	± 0	± 0
MID-ATLANTIC	6.54E-04	6.07E-05	0.00E+00	1.16E-04
	4.66E-06	4.16E-07	0.00E+00	7.85E-07
	90	8	0	16
	± 71	± 24	± 0	± 31
NEAR SHORE	2.76E-04	0.00E+00	0.00E+00	0.00E+00
	1.84E-06	0.00E+00	0.00E+00	0.00E+00
	11	0	0	0
	± 24	± 0	± 0	± 0
MID-SHELF	7.74E-04	1.63E-04	0.00E+00	2.78E-04
	5.19E-06	1.11E-06	0.00E+00	1.89E-06
	41	9	0	15
	± 52	± 28	± 0	± 33
NEW YORK BIGHT	2.73E-05	0.00E+00	0.00E+00	0.00E+00
	1.35E-07	0.00E+00	0.00E+00	0.00E+00
	2	0	0	0
	± 9	± 0	± 0	± 0
SHELF EDGE	7.65E-04	0.00E+00	0.00E+00	0.00E+00
	5.69E-06	0.00E+00	0.00E+00	0.00E+00
	47	0	0	0
	± 57	± 0	± 0	± 0
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	320	108	81	18
	± 150	± 76	± 117	± 34

*Study area OCS does not include the slope water regions.

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Balaenoptera musculus - Blue whale - Endangered Species

INTRODUCTION

1981 Data. *B. musculus* was not sighted during 1981.

Number of Sightings. *B. musculus* was seen only twice, but not in the study area. The 2 sightings of 2 individuals accounted for less than 1% of the large whale sightings and less than 1% of the baleen whale sightings during the 3 year survey period.

Individuals per Sighting. A group size of 1 individual was found for both blue whale sightings.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The first CETAP sightings of blue whales were recorded on 19 August 1980 outside of, but close to, the study area. Two sightings, each of a single animal, occurred approximately 70 miles southeast of Cape Sable, Nova Scotia. The locations are shown in Figure 14. The sightings were roughly 45 miles northeast of the easternmost point in the CETAP study area.

The normal range for blue whales in the Northwest Atlantic is believed to extend from the Nova Scotia/Gulf of St.Lawrence region northwards toward the Arctic ice pack (Sergeant, 1966; Sutcliffe and Brodie, 1977). The precise southern limit of this species' range remains

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unknown (Katona et al., 1978). Although Katona et al. (1978) did report a number of blue whale strandings within the study area, to date no confirmed live sightings of the species have been recorded from the area. However, present data indicate that *B. musculus* does occur close by.

Feeding. Feeding was reported for one of the sightings of 19 August 1980. This sighting was about 45 miles beyond the eastern boundary of the study area.

Calves and Juveniles. No blue whale calves or juveniles were sighted during the 39 months of field studies reflected in this report.

Areas. No sightings were found within Lease Sale Areas 40, 49, 59, 42, or Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. An abundance estimate of 11 (no CI) for Nova Scotia sampling block 3 in August 1980 was the only population estimate for the blue whale.

ENVIRONMENTAL DATA

Water Temperature (°C). The water temperature found for the 2 blue whale sightings was 17.5°C, a considerably warmer value than that found for the other 5 baleen species. However, since there were only 2 sightings, it is difficult to evaluate the significance of this.

Depth (m). The average depth for blue whale sightings was 201m, with a range from 128 to 274m.

BEHAVIOR

Migration and Movement. Insufficient information exists from the 2 CETAP sightings on which to base any hypothesis regarding migration or movements of blue whales.

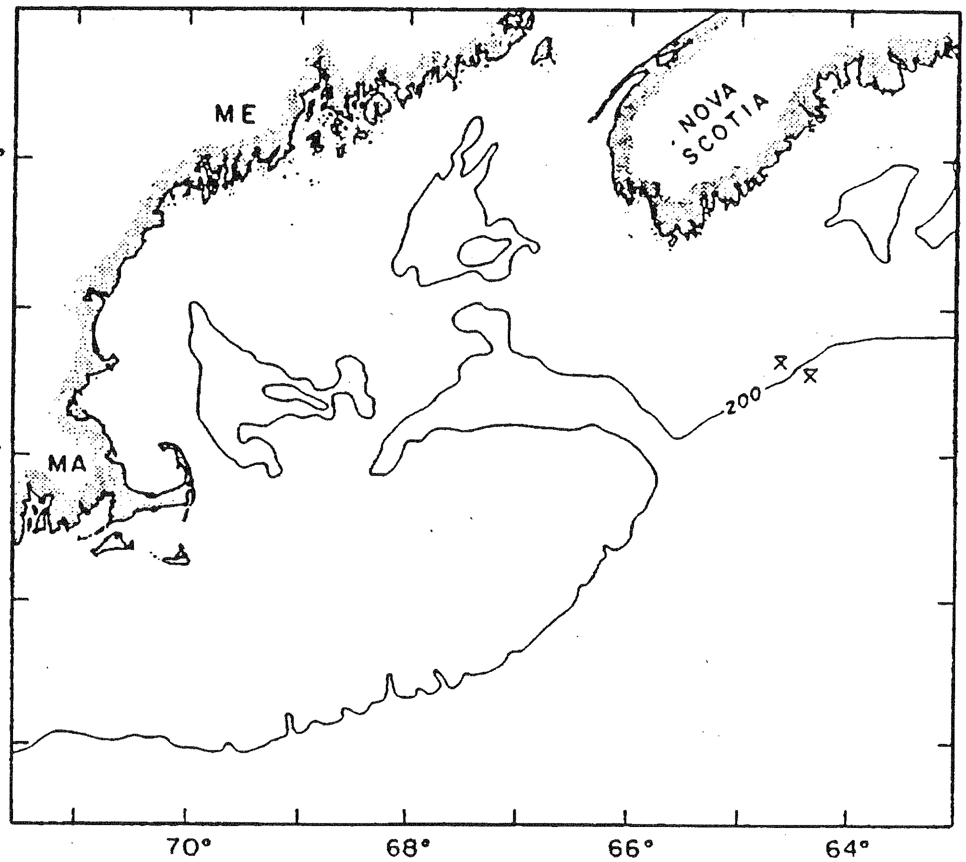

Figure 14. All sightings of the blue whale, *Balaenoptera musculus*, for the 39 month period -- 1 November 1978 through 28 January 1982.

Physeter catodon - Sperm whale - Endangered Species

INTRODUCTION

1981 Data. The 1981 data were consistent with the findings reported in 1979 and 1980. The single exception resulting from analysis of the accumulated data showed that the occurrence of the sperm whale in the shelf waters south of New England takes place in spring, in addition to summer and fall as previously reported.

Number of Sightings. *P. catodon* was the fifth most commonly sighted large whale in the study area. The 341 sightings of 1034 individuals accounted for 8% of the large whale sightings and 7% of the odontocete whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 3.0, the third greatest for all large whale species. The mode was 1, with a range from 1 to 100. This relatively small group size was typical of most large whale species.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The sperm whale has a four-season distribution along the shelf edge throughout the study area (Figures 15a-d). While this distribution is centered about the 1000 m depth contour, it extends seaward of the 2000 m contour into the deep ocean over all seasons. These data are consistent with observations reported by

Townsend (1935), Brown (1959), and Slijper et al. (1964), and indicate that the distribution of the sperm whale continues well beyond the shelf edge, over the continental slope, and into the mid-ocean regions. The distribution also extends shoreward, and inshore of the 100 m contour, but in a more narrowly defined area. This occurrence takes place south of Block Island, Martha's Vineyard, and Nantucket. It extends from May through November, but is most common from August to November (20 of 30 total sightings in this area). These sightings have occurred at locations as shallow as 60 m, and are believed to be related to the presence of squid, a known prey item.

Inspection of the seasonal sighting distribution along with the relative abundance data shown in Figures 15c-d indicates how the distribution and abundance of sperm whales change over the course of the year. In winter, sperm whales are concentrated in the southernmost portion of the study area directly east and northeast of Cape Hatteras. This region contains the highest relative abundance values reported for any time and place within the study area. However, there are also scattered occurrences at low to moderate abundance levels all along the shelf edge to the northern boundary of the study area. In spring the center of concentration shifts northward to east of the Delmarva Peninsula, and is generally widespread along the shelf edge throughout the central portion of the Mid-Atlantic Bight. There is also a more widespread occurrence along the southern margin of Georges Bank. The summer distribution is similar to spring's, with two exceptions: 1)the on-shelf occurrence south of New England has become well-established, and 2)sperm whale distribution has extended east and north of Georges Bank into the Northeast Channel region. In the fall, the on-shelf area south of New England experiences its highest abundance levels. Throughout all four seasons, the mid-Atlantic Bight has remained an area of concentration for the species, although there are indications of a southward shift in winter.

Feeding. There were few, scattered sightings of surface feeding sperm whales, only 2% of the total sightings. These feeding sightings, like the general sightings, were concentrated primarily along the shelf break, throughout the entire study area (Fig. 15e).

Sperm whales are deep-diving, primarily squid eaters (Caldwell et al., 1966; Gambell, 1972). The relative paucity of observations of feeding sperm whales is undoubtedly due to their sub-surface feeding behavior. Given their apparent year-round feeding habits (Gambell, 1972), it is likely that all the areas in which sperm whales were sighted are also areas of feeding.

Sperm whales were seen feeding at the surface only once in the Lease Areas (Proposed Area 52) . However, there were numerous sightings of sperm whales in all Lease Areas under study (Fig. 15a). Therefore, it is probable that sperm whale feeding occurs in all the Lease Areas.

Calves and Juveniles. During the three year survey, 32 sightings of sperm whale calves or juveniles were reported. Figure 15f shows their distribution. Calves were seen along the shelf edge and seaward, from Cape Hatteras to the Gulf of Maine. This distribution parallels that of sperm whale adults. During the spring, calves were sighted beyond the shelf edge from North Carolina to the southern tip of New Jersey (8 sightings). During the summer, the range of calf sightings was more extensive (22 sightings); calves were seen from Cape Hatteras to the eastern edge of the Gulf of Maine. Calves were sighted once during the fall, and once during the winter near the shelf edge at the latitudes of Delaware and Virginia, respectively.

Katona et al. (1978) reported that mating among sperm whales occurs during the northward spring migration and that pregnancy lasts 14-16 months. The birth of calves then would be expected late in summer or early in fall. This may explain the high frequency of calf sighting during summer relative to those during spring. The scarcity of fall and winter calf sightings may be an artifact of reduced sighting effort.

Four instances of apparent nursing were reported, 3 during spring, and 1 during summer, all by calves seen near the shelf edge, east of Maryland and Virginia. Spring nursing is not inconsistent with summer births since lactation among sperm whales is believed to continue 1-2 years after parturition (Katona et al., 1978).

Calves were found among adult groups ranging in size from 2 to 24 animals.

During summer, 5 calves were found within Lease Sale Areas 40, 49, and 59, and 2 calves were found within Proposed Lease Sale Area 52. During the fall, 1 calf was found within Lease Sale Areas 40, 49, and 59. No calves were found within Lease Sale Area 42.

Areas. The sperm whale occurs commonly and widespread throughout the Mid-Atlantic Lease Sale Areas (40, 49, 59). In the North Atlantic, the species also occurs commonly and widespread throughout Proposed Lease Sale 52, but infrequently in Lease Sale 42. Of the endangered species of cetaceans, the sperm whale is the most common within the Lease Sale Areas 40, 49, 59, and Proposed Lease Sale 52. The occurrence there is more common in spring and summer, and may involve some sexual and social segregation females and juveniles being more common in the Mid-Atlantic, and males more common in the North Atlantic.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 12 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 15g. The peak average estimated abundance of sperm whales in the Study Area was 222 (+/- 240) and occurred during spring. The average estimated abundance in the Study Area during summer was nearly as high at 216 (+/- 204). Correspondingly, the peak average estimated abundance of this species in waters defined as Continental Slope was 444 (+/- 5793) during the summer. The maximum point estimate of abundance for this species was 290 (+/- 433) for sampling block S during July 1981. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. The estimates for this species are undoubtedly negatively biased due to animal diving behavior, as well as other factors.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 134 sightings of this species. The average water temperature for sperm whale sightings was 17.7°C, the warmest for all large whales, and fifth warmest for all odontocetes. The mode was 24.0 with a range from 8.0 to 26.8°C. Ninety percent of these sightings were found in a wide water temperature range from 9.5 to 26.0°C. This may be explained by the wide latitudinal range of sightings along the shelf edge from Cape Hatteras to the Gulf of Maine.

Depth (m). The average depth for sperm whale sightings was 1792m, the deepest for all large whales, and third deepest for all odontocetes. The mode was 1829, with a range from 13 to 4148m. Ninety percent of these sightings were made over depths ranging from 72 to 3567m. A majority of sightings were found in moderately deep to deep water, which corresponds with the sighting concentration along the shelf edge.

BEHAVIOR

Associations. P.catodon was observed with another cetacean species in 10% of its sightings. Sixty-eight percent of these associations involved only one additional species, typically another odontocete. Unidentified dolphins, Globicephala spp., and T.truncatus were the common species observed with sperm whales. Four other dolphin species (refer to Table 30 page) have been reported near or, bowriding ahead of P.catodon. Generally, sperm whales have been only infrequently observed with other species, predominantly with the more common and widespread shelf edge inhabiting small whale species.

Migration and Movement. The seasonal changes in sperm whale distribution and abundance may be due to a combination of localized feeding-related movements and longer distance migrations related to both reproduction and social organization. The general description of sperm whale migrations is that there is a fairly constant concentration in tropical and subtropical latitudes between 30°N and 10°S. There is a seasonal north-south migration characterized by sexual segregation and social grouping. The northern limit to migrations of mixed schools of females and juveniles is believed to be about 40°N or the 20°C isotherm. Medium and large males migrate further, and to higher latitudes (Slijper et al., 1964; Best, 1979). This is in agreement with catch records from a Nova Scotian fishery, 1966-1972, where 99 of 101 sperm whales taken were males (Sutcliffe and Brodie, 1977). The CETAP data are consistent with this pattern, and suggest that many or most of the sightings early or late in the year, and sightings in the northern portion of the study area throughout the year are likely to be males. The general pattern for the study area is that the high wintertime abundance of sperm whales off Cape Hatteras, with the likely addition of individuals arriving in the area from more southerly waters, expands northward along the shelf edge in the spring. In summer, the northward expansion continues to eastern Georges Bank and up into the Northeast Channel region. There is also an incursion into the shelf waters south of New England. In fall, the continuing shift into this shelf area, presumably for feeding, results in the highest relative abundance value for the season, and the second highest for any time or place within the study area. In winter, the data suggest a general southward shift, with some individuals departing the study area completely. However, as is true for most other species, no migration or movement affects the entire stock or population. For example, even in winter, sperm whales continue to be present at low to moderate levels all along the southern margin of Georges Bank.

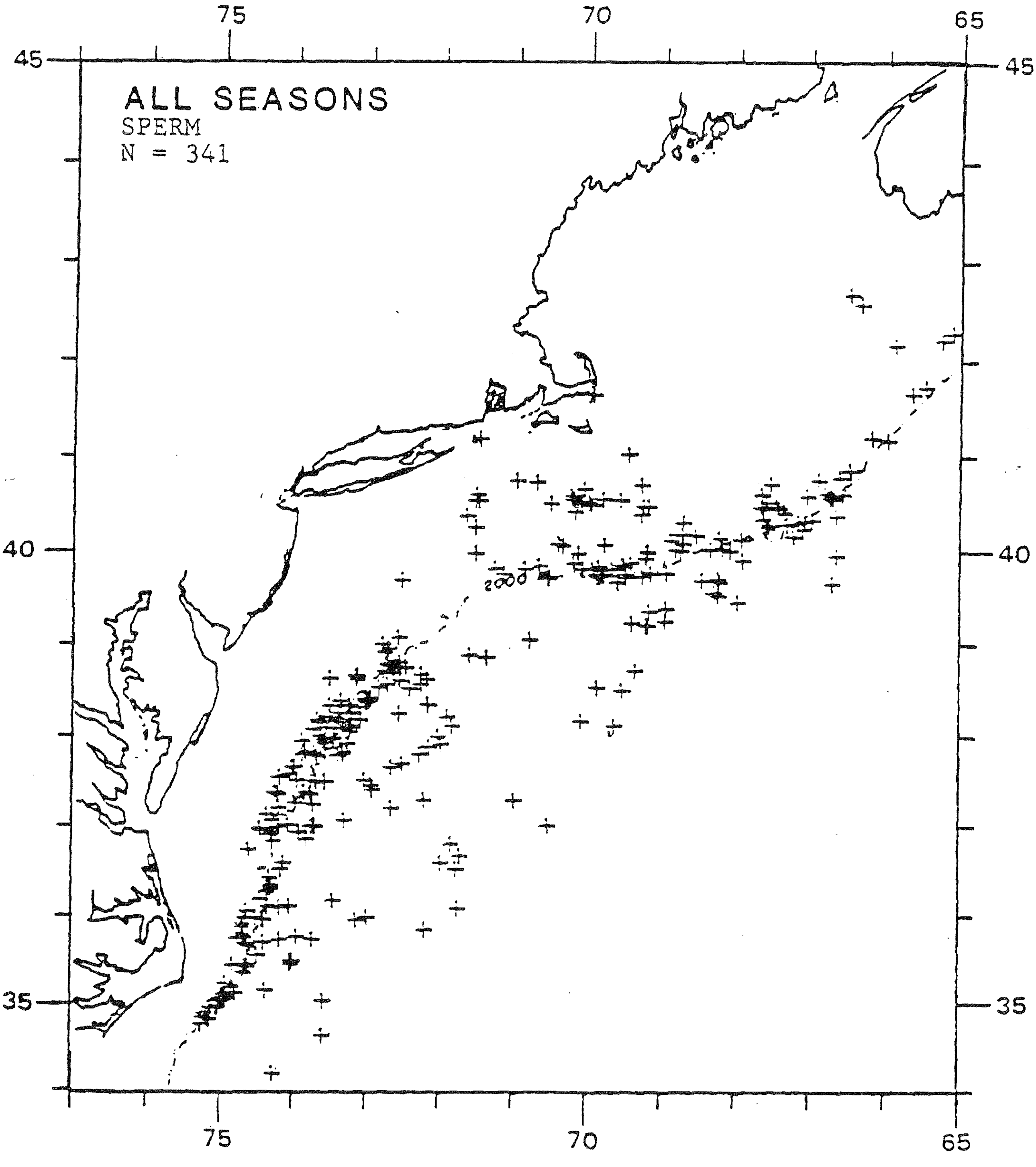

Figure 15a. All sightings of the sperm whale, Physeter catodon, for the 39 month period -- 1 November 1978 through 28 January 1982.

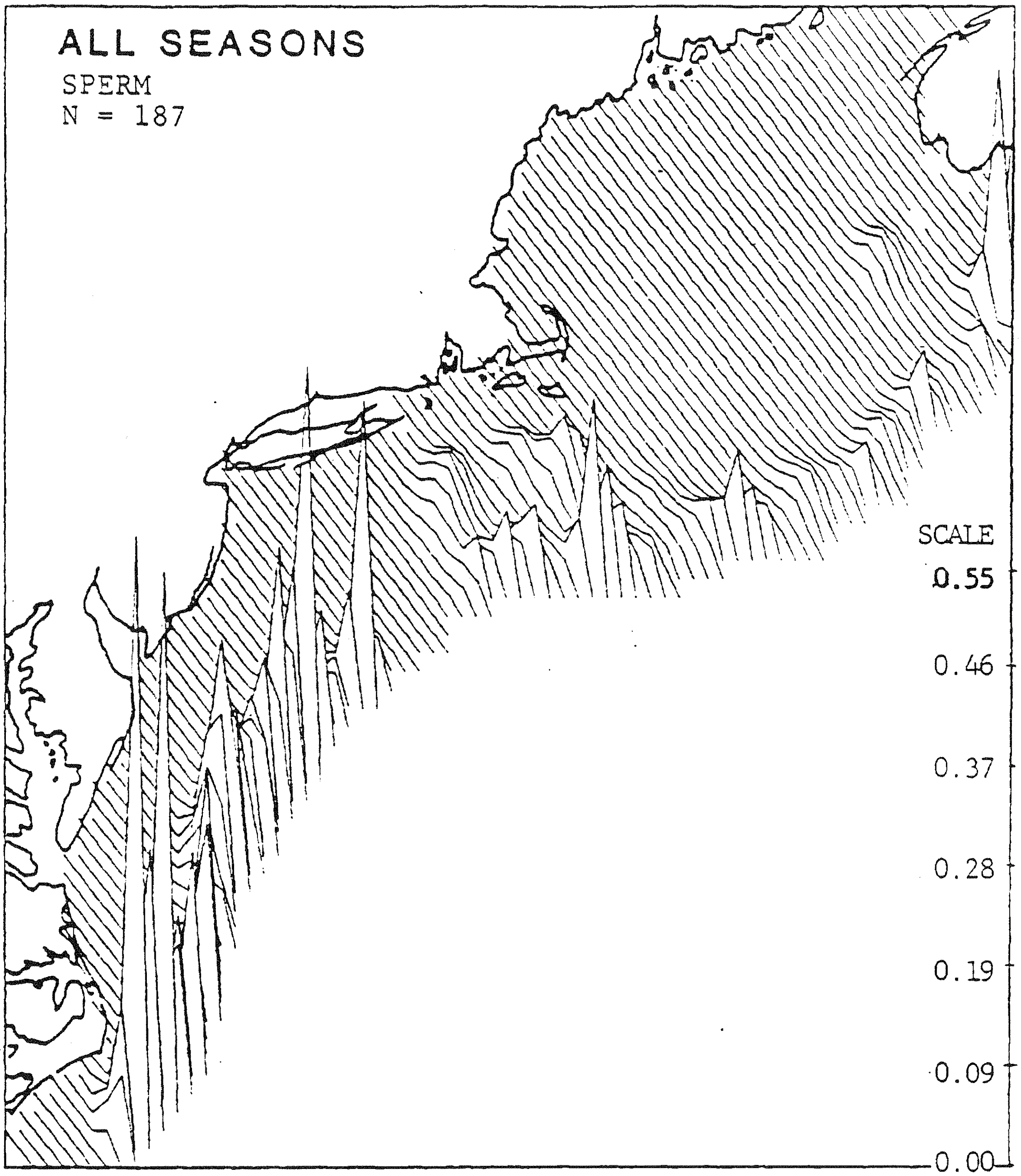

Figure 15b. The relative abundance of P. catodon for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

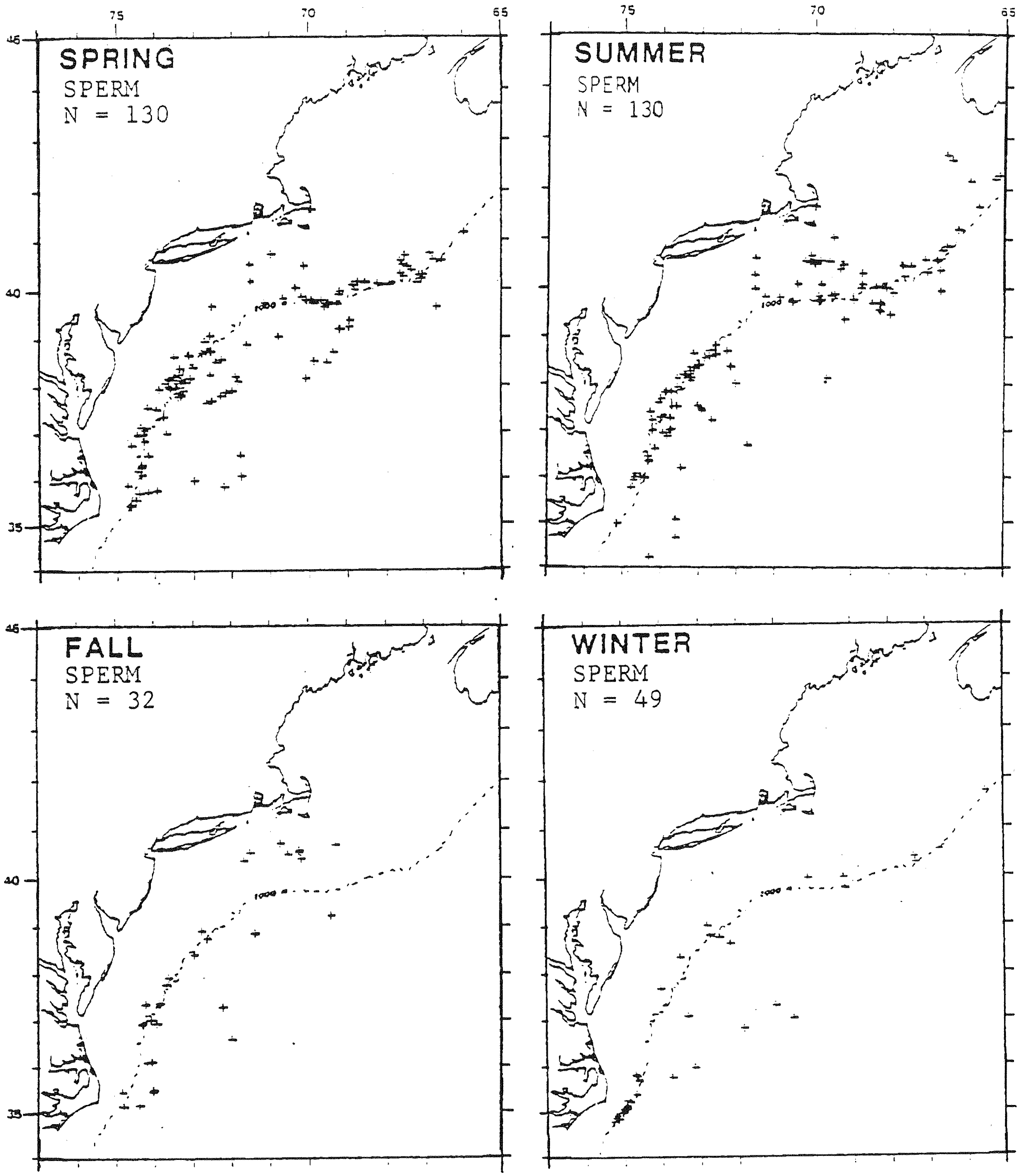

Figure 15c. The sighting distribution of P. catodon by season.

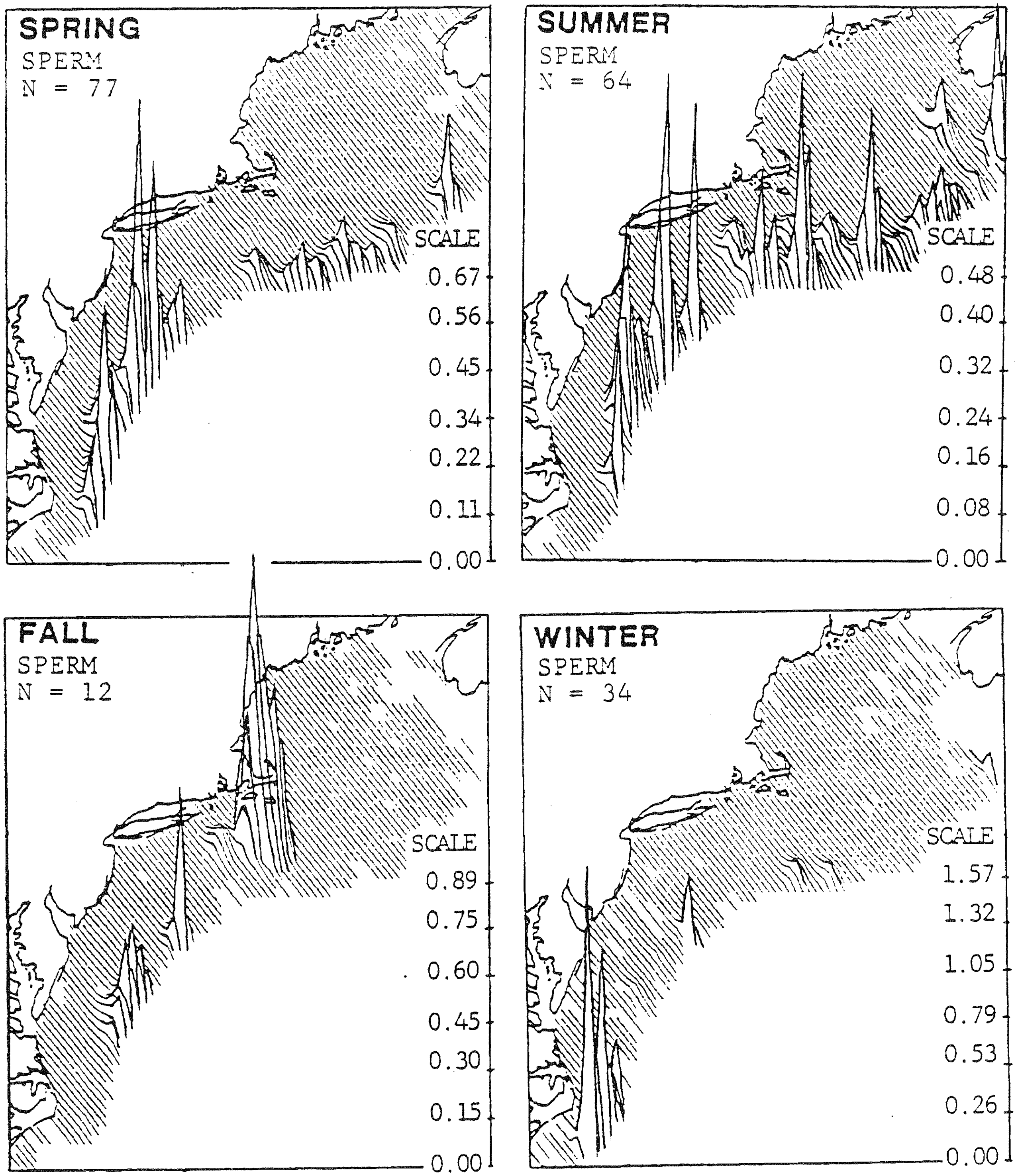

Figure 15d. The relative abundance of P. catodon by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

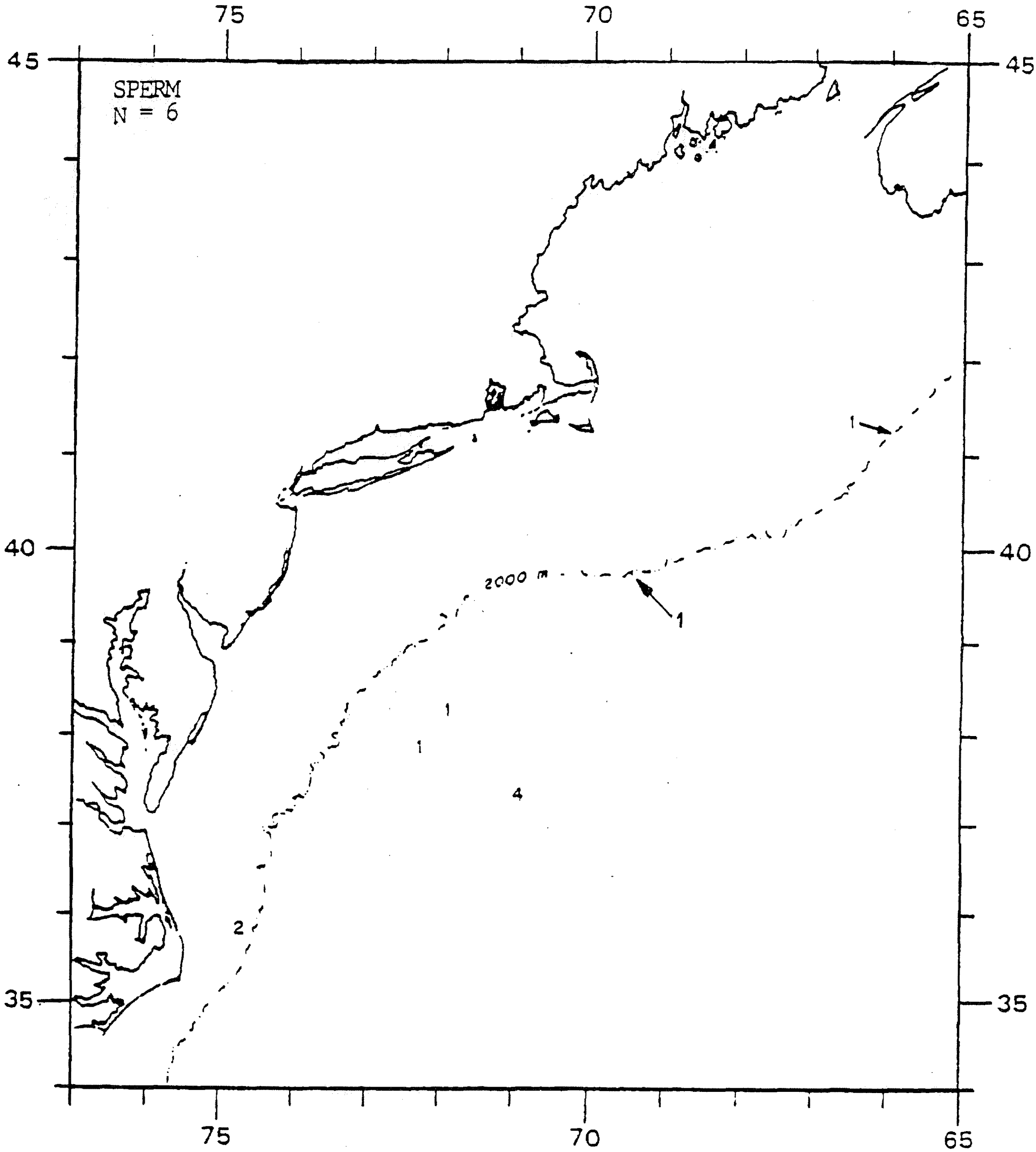

Figure 15e. Locations of sightings of feeding or apparent feeding of *P. catodon* . The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

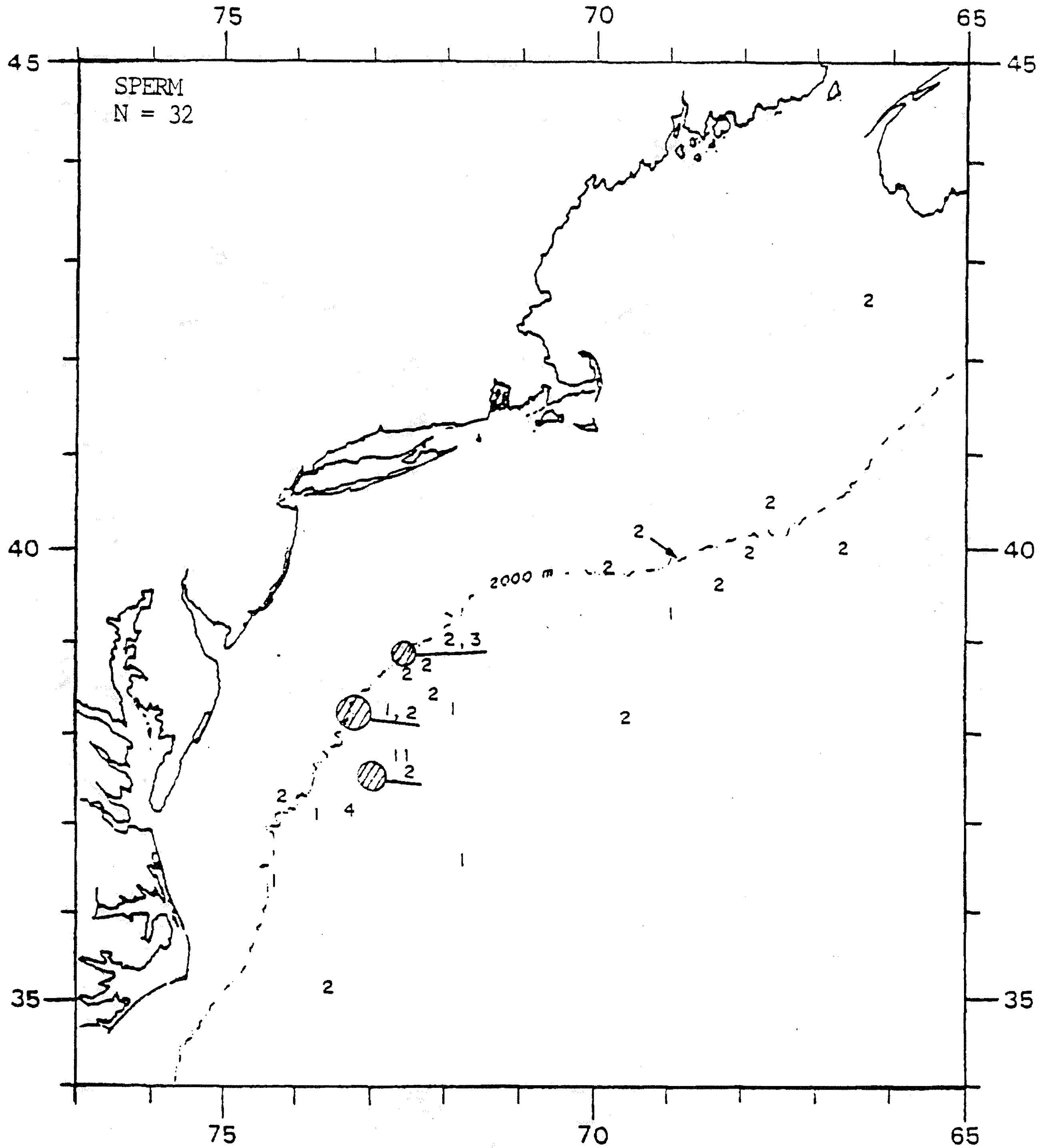

Figure 15f. Sightings of calves or juveniles of P. catodon. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

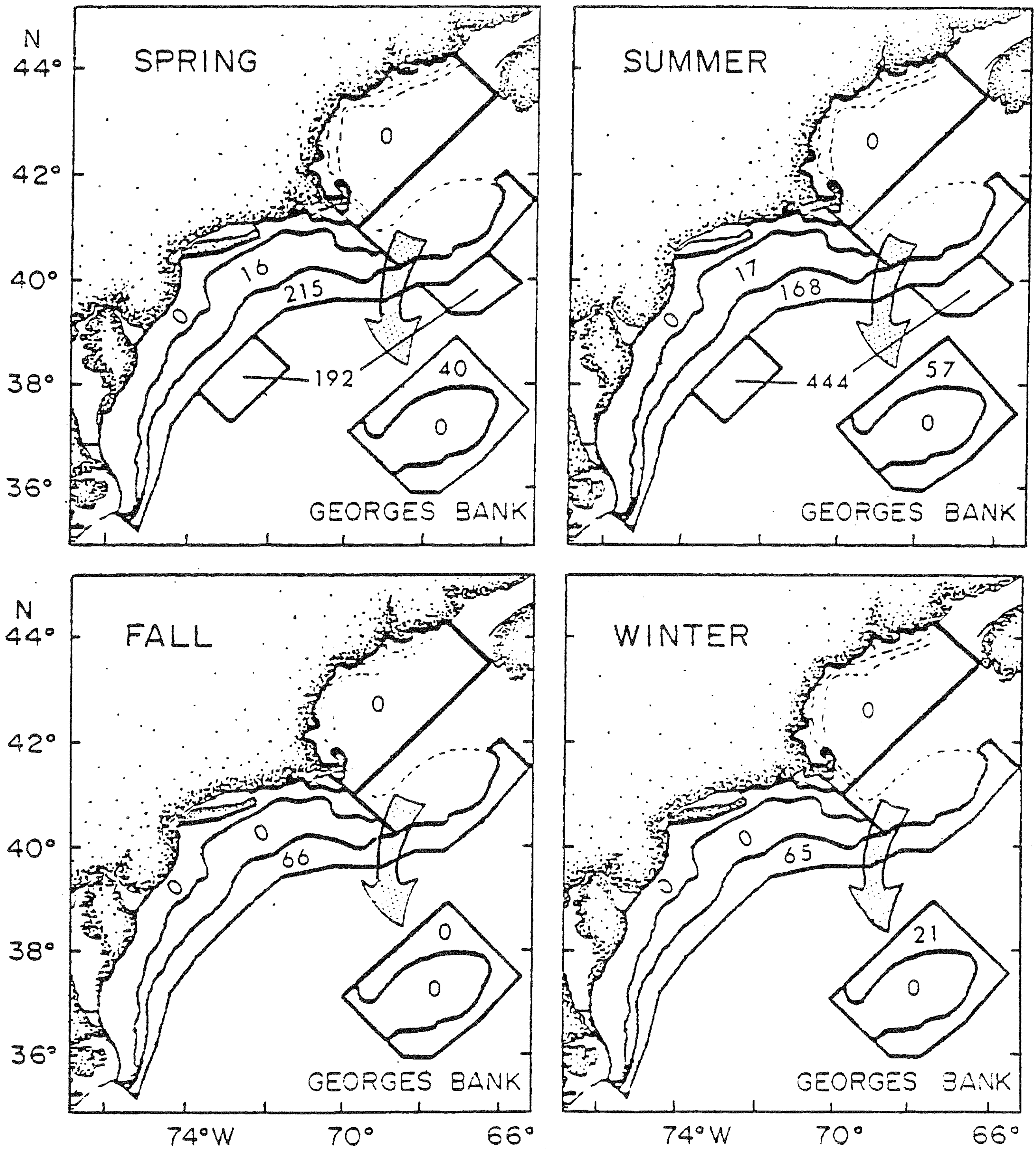

Figure 15g. Estimates of the number of individuals of P. catodon by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 12. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Physeter catodon*.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
GEORGES BANK	5.15E-04	7.23E-04	0.00E+00	2.22E-04
	1.13E-05	1.39E-05	0.00E+00	1.87E-06
	36	50	0	15
	± 77	± 98	± 0	± 40
<50 FATHOMS	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
>50 FATHOMS	1.08E-03	1.56E-03	0.00E+00	5.77E-04
	2.39E-05	2.99E-05	0.00E+00	4.87E-06
	40	57	0	21
	± 89	± 111	± 0	± 54
LEASE SALE 52	2.09E-03	1.78E-03	0.00E+00	4.25E-04
	4.18E-05	3.15E-05	0.00E+00	4.15E-06
	58	50	0	12
	± 93	± 95	± 0	± 31
MID-ATLANTIC	1.24E-03	1.11E-03	2.80E-04	2.81E-04
	3.98E-05	2.00E-05	4.23E-06	1.86E-05
	170	152	38	39
	± 209	± 167	± 84	± 150
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	3.05E-04	3.27E-04	0.00E+00	0.00E+00
	1.96E-06	3.17E-06	0.00E+00	0.00E+00
	16	17	0	0
	± 32	± 48	± 0	± 0
NEW YORK BIGHT	4.28E-04	1.01E-03	2.71E-04	0.00E+00
	4.59E-06	1.47E-05	4.58E-06	0.00E+00
	27	63	17	0
	± 55	± 105	± 68	± 0
SHELF EDGE	3.47E-03	2.71E-03	1.06E-03	1.04E-03
	1.13E-04	5.42E-05	1.60E-05	5.38E-05
	215	168	66	65
	± 256	± 189	± 150	± 197
CONTINENTAL SLOPE	6.21E-03	1.44E-02	.	.
	8.42E-05	4.36E-04	.	.
	192	444	.	.
	± 237	± 5793	± .	± .
STUDY AREA OCS*	222	216	51	57
	± 240	± 204	± 111	± 171

*Study area OCS does not include the slope water regions.

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Orcinus orca - Killer whale

INTRODUCTION

1981 Data. O. orca was sighted on four occasions during 1981, in the months of May, June, September, and October in scattered locations. Two sightings were reported near the OCS edge east of New Jersey, another in coastal waters just east of Long Island, and one in coastal waters near Cape Hatteras. Two of these sightings were given "probable" I.D. reliabilities, and two were reported as "sure".

Number of Sightings. O. orca was an infrequently sighted large whale. The 12 sightings of 85 individuals accounted for less than 1% of the large whale sightings and less than 1% of the odontocete sightings.

Individuals per Sighting. The average number of individuals per sighting was 7.1, the largest for all large whale species. The mode was 1, with a range from 1 to 40.

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SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *O. orca* was found in both shallow and deep waters from Cape Ann in the north to Cape Hatteras in the south (Figure 16a). Six sightings were reported near the OCS edge, 4 east of New Jersey, 1 east of Long Island, and 1 east of Cape Hatteras. The remaining sightings were found in coastal waters near Cape Ann, Cape Cod, Long Island, and Cape Hatteras.

Katona et al.(1978) and Schmidly (1981) report a distribution for this species in the Western North Atlantic from the polar pack ice south to Florida, the Lesser Antilles, and into the Gulf of Mexico.

Feeding. No sightings of apparent feeding were reported. However, like many cetaceans, and particularly odontocetes, feeding is predominantly sub-surface. Therefore, feeding can be inferred for most areas where sightings occurred.

Calves and Juveniles. During the three year survey period, only one sighting of a calf or juvenile was reported; a calf was seen on 5 September 1979 among a group of 40 killer whales in waters near Cape Ann (Figure 16b). The scarcity of calf sightings is not surprising since killer whale adults were seen only 12 times.

No information is available about reproductive behavior in the Northwest Atlantic, but in the North Pacific, births are concentrated in the late summer or autumn (Katona, et al., 1978).

The calf sighting was not found within BLM Lease Sale Areas 40, 42, 49, or 59, or within Proposed Lease Sale 52.

Areas. No sightings were found within Lease Sale Areas 40, 49, and 59, or 42 or within Proposed Area 52. However, some sightings were reported from locations close to Area 42 and Proposed Area 52.

ENVIRONMENTAL DATA

Water Temperature (°C) - Sea surface temperature was not available for the 12 sightings of killer whales.

Depth (m). The average depth for *O. orca* sightings was 1492m, the second deepest for all large whales, and fifth deepest for all odontocetes; the mode was 42, with a range from 42 to 5121m.

BEHAVIOR

Associations. *Orcinus orca* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient information.

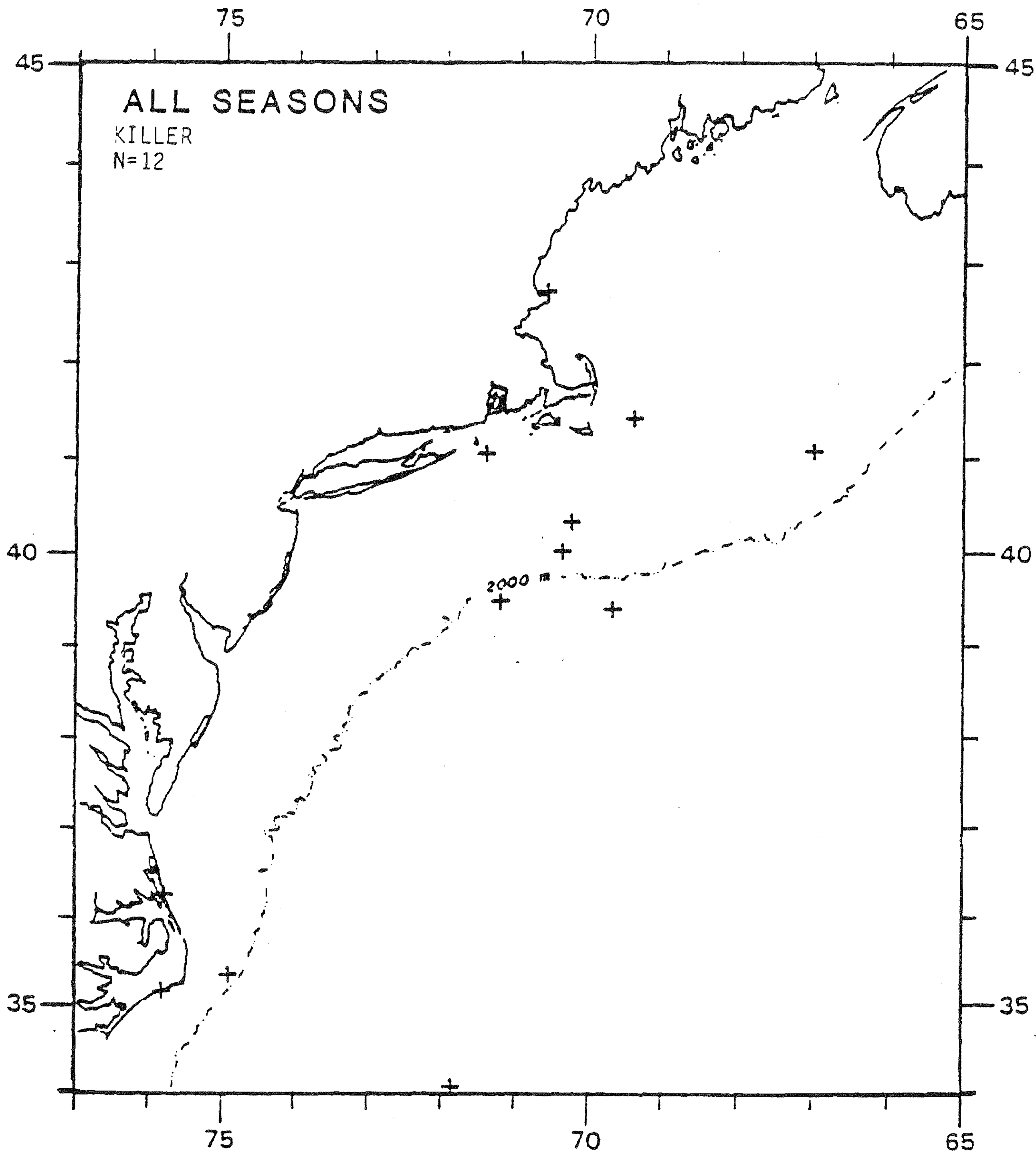

Figure 16a. All sightings of the killer whale, Orcinus orca, for the 39 month period -- 1 November 1978 through 28 January 1982.

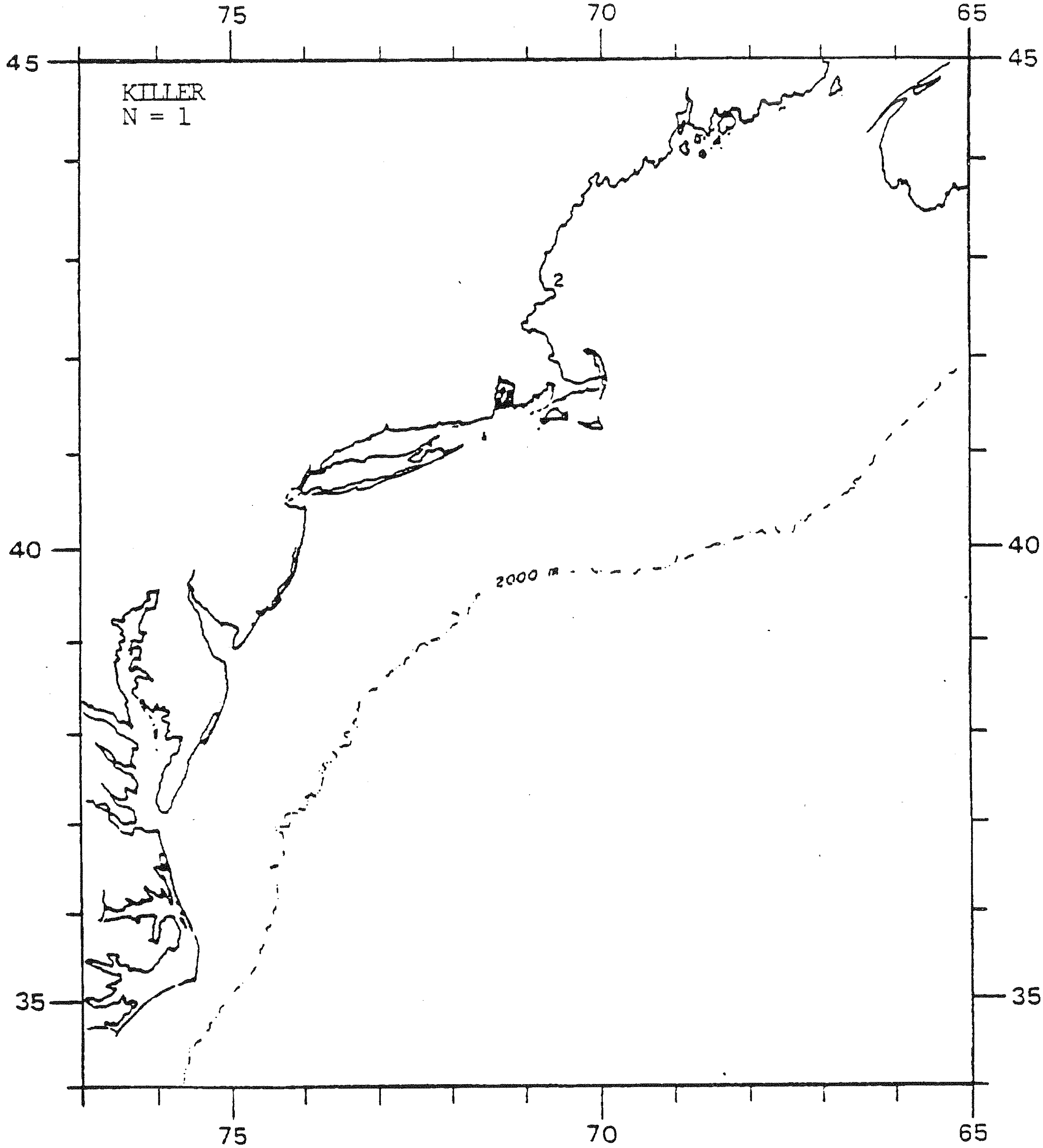

Figure 16b. Sightings of calves or juveniles of O. orca. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

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Hyperoodon ampullatus - Northern bottlenosed whale

INTRODUCTION

1981 Data. *H. ampullatus* was sighted once during 1981.

Number of Sightings. *H. ampullatus* was seen only rarely in the study area. The 2 sightings of 3 individuals accounted for less than 1% of either the large whale or odontocete sightings.

Individuals per Sighting. The average group size for the 2 sightings was 1.5; two individuals were found in one sighting, and one individual in the other.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. One sighting was reported on 30 May 1980 east of Cape Cod along the 2000 meter depth contour. The second sighting was also found along the OCS edge, but east of Cape May, on 12 June 1981. The locations of these sightings are shown in Figure 17.

Feeding. Feeding was not observed in this species, however like other odontocetes, it it not unreasonable to assume feeding throughout the range.

Calves and Juveniles. No calves of this species were sighted.

Areas. One sighting (June 12, 1981) was found within Lease Sale Area 40, 49, and 59. No sightings were found within Area 42 or Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. An abundance estimate of 34 (no CI) for sampling block G, stratum z, in June 1981 was the only population estimate for the northern bottlenosed whale.

ENVIRONMENTAL DATA

Water Temperature (°C). Individuals were found in 11.0°C water in one sighting, and in 17.8°C water in the other.

Depth (m). Two depths were recorded for *H. ampullatus* sightings, 1417m and 2377m.

BEHAVIOR

Associations. *Hyperoodon ampullatus* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movements. Insufficient information.

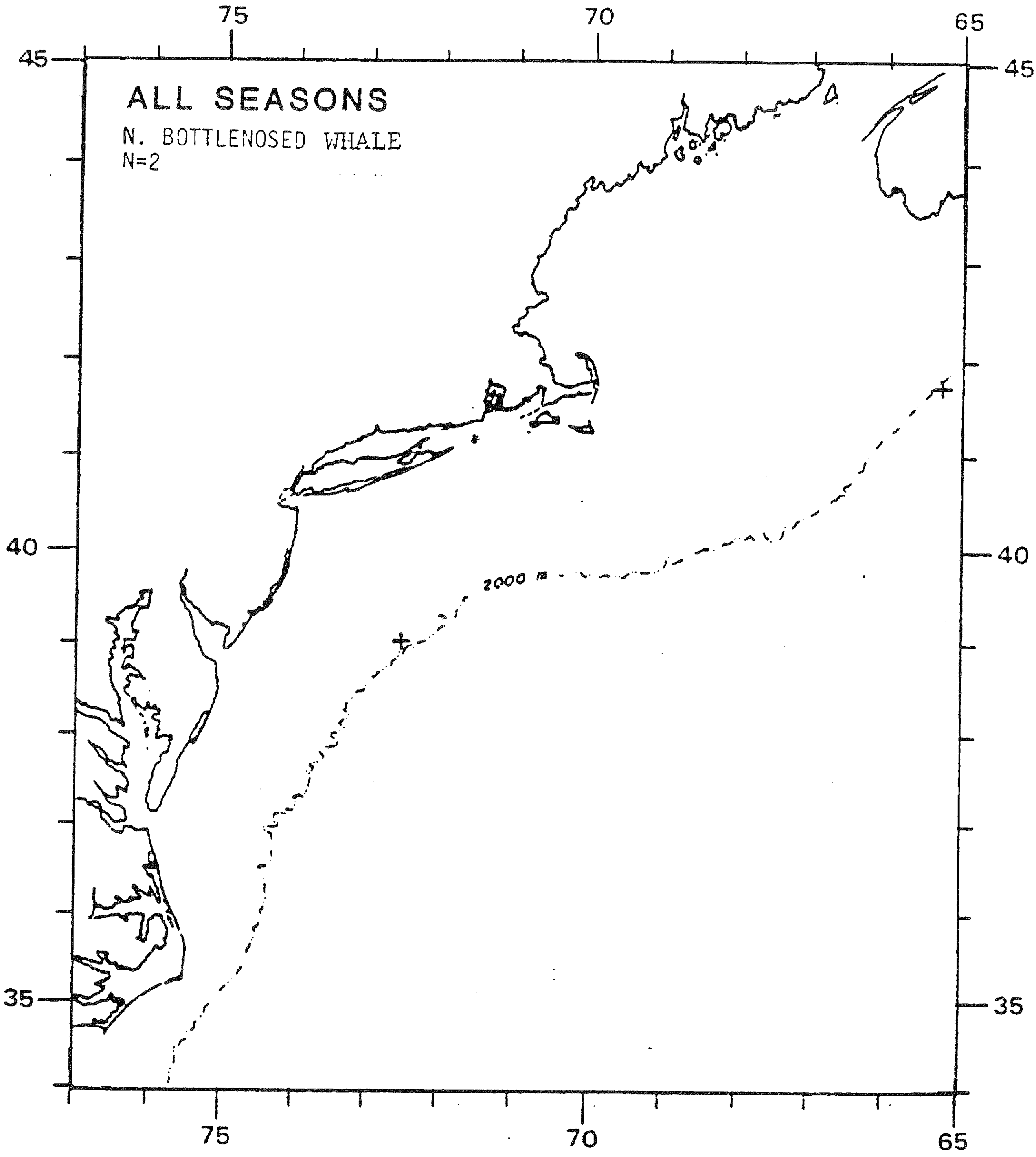

Figure 17. All sightings of the northern bottlenosed whale, Hyperoodon ampullatus, for the 39 month period -- 1 November 1978 through 28 January 1982.

Tursiops truncatus - Bottlenosed dolphin

INTRODUCTION

1981 Data. The 1981 data were consistent with the data from CETAP studies in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. *T. truncatus* was the most commonly sighted small whale in the study area. The 1025 sightings of 15,133 individuals accounted for 24% of the small whale sightings and 22% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 14.8, the fifth smallest for small whales. The mode was 2, with a range from 1 to 350.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *T. truncatus* has a distinct J-shaped distribution within the study area (Figures 18a-d). This consists of a elongate offshore portion and a somewhat more abbreviated nearshore portion. The offshore distribution occurs in a band along the shelf edge extending from Cape Hatteras northeastward to the eastern tip of Georges Bank. This distribution, similar to that of several other odontocetes, is centered about the 1000 m depth contour but includes both on-shelf and deep ocean sightings. The nearshore distribution follows closely the coastline from south of Cape Hatteras to Cape Henlopen, DE. The shelf edge population of *Tursiops* remains similar in distributional range and abundance levels from spring through fall. That is, the distribution extends throughout all or most of the study area at abundance levels in the top 20th percentile for any shelf-edge cetacean. In winter, areas near Cape Hatteras and along the southern edge of Georges Bank continue to contain *Tursiops* at moderate to high levels. However, a large section of the Mid-Atlantic Bight is almost completely devoid of the species during this season. Like the offshore portion, the nearshore portion of the Tursiops population also has a seasonal component. It too has a relatively constant distribution and abundance during spring and summer, but is reduced and contracted southward in fall, and in winter the species is absent from the neashore portion of the study area. There are, however, numerous nearshore winter sightings just south of Cape Hatteras.

The seasonal nature of the nearshore distribution does raise a question. In examining catch data from the old Cape Hatteras *Tursiops* fishery, Mead (1975) found that catches were greatest during spring and fall, with few animals taken during the summer. The present data indicate a regular and common nearshore summer occurrence of *Tursiops*.

Feeding. Sightings of surface feeding bottlenosed dolphins coincided with the majority of general bottlenosed sightings, i.e., along the outer shelf break (Fig. 18e) throughout the study area. Sightings were made in all seasons except winter, most likely due to reduced effort during that period.

Bottlenosed dolphins are opportunistic feeders; they feed on fish, squid, and molluscs (Leatherwood, 1975). They have been observed to use innovative, cooperative behavior to feed on schools of fish (Hoese, 1971). The bottlenosed dolphins in this study appear to fall into an inshore and offshore population. The offshore group, represented by the shelf break sightings, undoubtedly feed in those same offshore waters. The lack of surface feeding observations indicates that most of their feeding is sub-surface. There was only 1 sighting of surface feeding inshore, however this population may also feed primarily subsurface.

Although relatively few feeding observations were made, over 50% of those observations were made within Lease Areas 40, 49, 59, and Proposed Area 52. That fact, combined with the extremely numerous sightings of bottlenosed dolphins within all the Lease Areas indicates that these Lease Areas are important feeding grounds for bottlenosed dolphins.

Calves and Juveniles. During the three year survey period, calves or juveniles were sighted on 119 occasions (Figure 18f). The distribution of calves closely paralleled the distribution of adults with sightings found along the edge of the continental shelf from Cape Hatteras to Cape Cod, and in shallow coastal waters from Cape Hatteras to Maryland. The number and distributional pattern of calf sightings was similar for the spring (38 sightings), summer (41 sightings), and fall (32 sightings) seasons. Only 8 sightings were reported during the winter, but their distribution extended throughout the range of the adult dolphin population.

For bottlenosed dolphins, ovulation may be induced rather than cyclic (Katona et al., 1978). If this is true, calves could be born throughout the year. This may explain the consistency in the numbers of calf sightings during spring, summer and fall, and in the wide geographic distribution of calves throughout the year. The reduced number of sightings during winter may be an artifact of reduced survey effort during that time.

Calves were found among adult groups ranging in size from 2 to 175 animals. One instance of apparent nursing was observed, during the spring along the shelf edge east of New Jersey.

Calf sightings were found within Lease Sale Areas 40, 42, 49, 59 and Proposed Lease Sale Area 52 during all seasons.

Areas.. *Tursiops truncatus* occurs commonly and widespread in the Mid-Atlantic Lease Sale Areas 40, 49, and 59 in spring, summer, and fall. The species is almost completely absent from these areas in winter. In the North Atlantic, the species has been infrequently sighted in Lease Sale 42, and only in the southern portion in the spring. In Proposed Lease Sale Area 52, *T.truncatus* is common and widely distributed during all four seasons.

POPULATION ESTIMATES AND STATUS

Population estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 13 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 18g. The peak average abundance for Atlantic bottlenosed dolphins in the Study Area was 8603 (+/- 4307) and occurred during spring. The peak average estimated abundance of this species in waters defined as the Shelf Edge was 7696 (+/- 10036) during fall. The maximum point estimate of abundance was 3847 (+/- 3495) for sampling block E, stratum z, during July 1980. Post-stratification of the 1979 data did not affect the maximum point abundance estimate.

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature was 18.8°C, the fourth warmest for all small whales and fourth warmest for odontocetes. The mode was 20.0 with a range from 6.3 to 28.1°C. Ninety percent of all sightings fall within a wide range of water temperatures (9.9 to 26.5°C). This is not unexpected since bottlenosed dolphins were found both inshore and along the shelf edge in a latitudinal range extending from Cape Hatteras to Cape Cod.

Depth (m). The average depth was 676m, the fourth shallowest for all small whales and fourth shallowest for odontocetes. The mode was 18 with a range from almost 0 to 4712m. Ninety percent of these sightings were made over a wide range of water depths (7 to 2158m). This is not surprising since one concentration of sightings was found in coastal waters south of New Jersey, and most of the remaining sightings were found along the shelf edge from Cape Hatteras to Georges Bank.

BEHAVIOR

Associations. Multispecies associations were reported in 10% of all sightings of bottlenose dolphins. Of these 102 sightings, 75% occurred in the presence of just one additional species, usually *Globicephala* spp. (71% of total *Tursiops* associations). In a majority of these occasions, these two species were reported in closely intermingled groups, often (20% of *Tursiops* associations; 26% of *Globicephala* associations) with calves or juveniles present. This common association has been observed and commented on by Norris and Prescott (1961), and Norris and Dohl (1980) for waters of the northeastern Pacific Ocean. Those authors suggested that this association is related to food searching and the advantage gained through association with other species that are presumed to have more efficient food-finding capability. Other associations between *Tursiops* and at least 5 species of large whale or 4 other small-whale species were infrequent or rare and are summarized in Table 30.

Migration and Movement. Katona et al., (1978) have summarized reports which indicate a southward migration of Tursiops in the fall, a return northward migration in the spring, and an increased abundance during winter in Florida waters. The CETAP data are consistent with this pattern. However, as with many other cetacean species, the data show that the migration does not completely empty the area of all individuals of the species. For example, *Tursiops* occurs along the southern edge of Georges Bank throughout the year. This includes the winter season, when much or most of the population has migrated south. These individuals may have previously been in the area or themselves recently arrived from more northerly areas.

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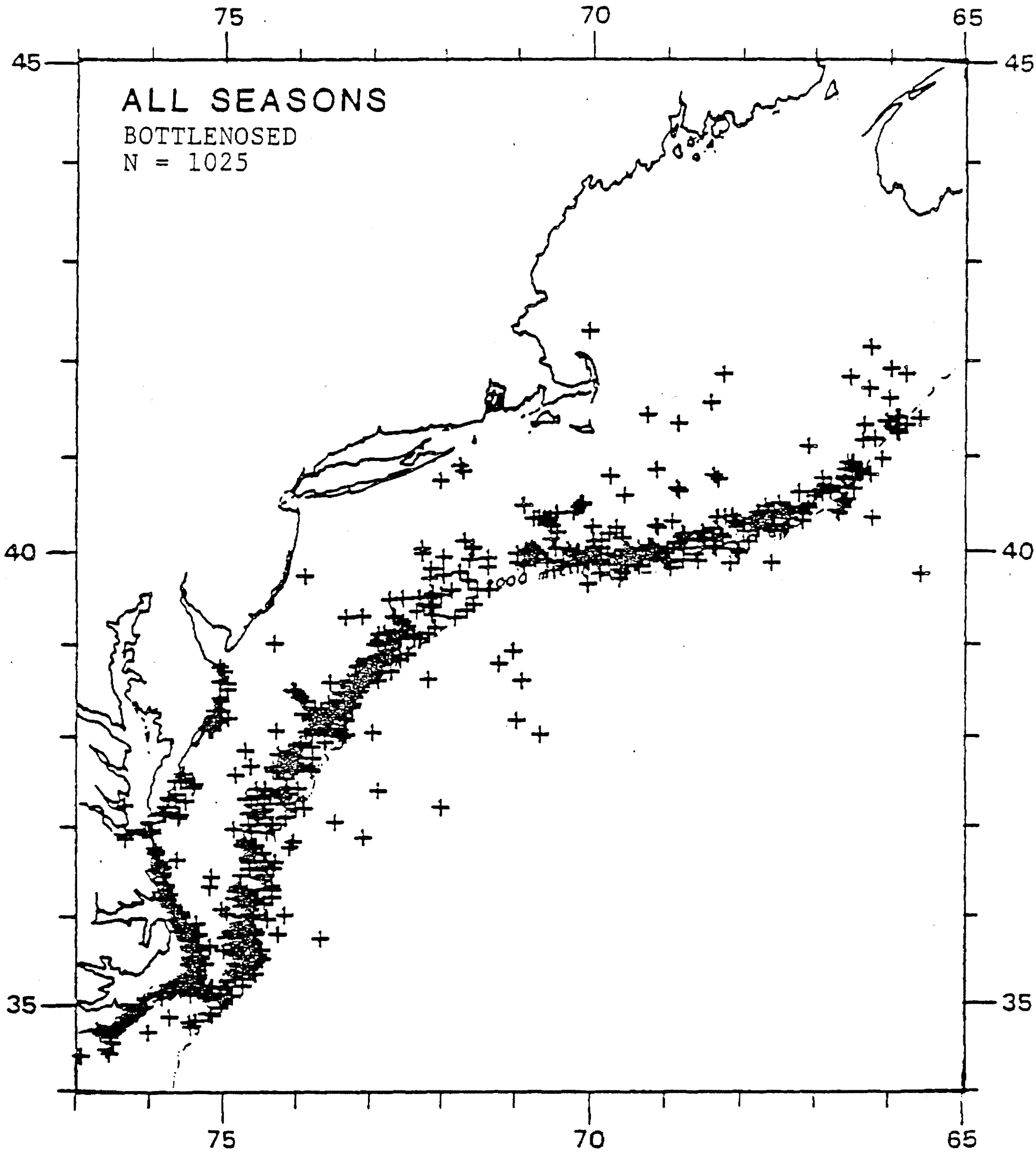

Figure 18a. All sightings of the bottlenose dolphin, *Tursiops truncatus*, for the 39 month period -- 1 November 1978 through 28 January 1982.

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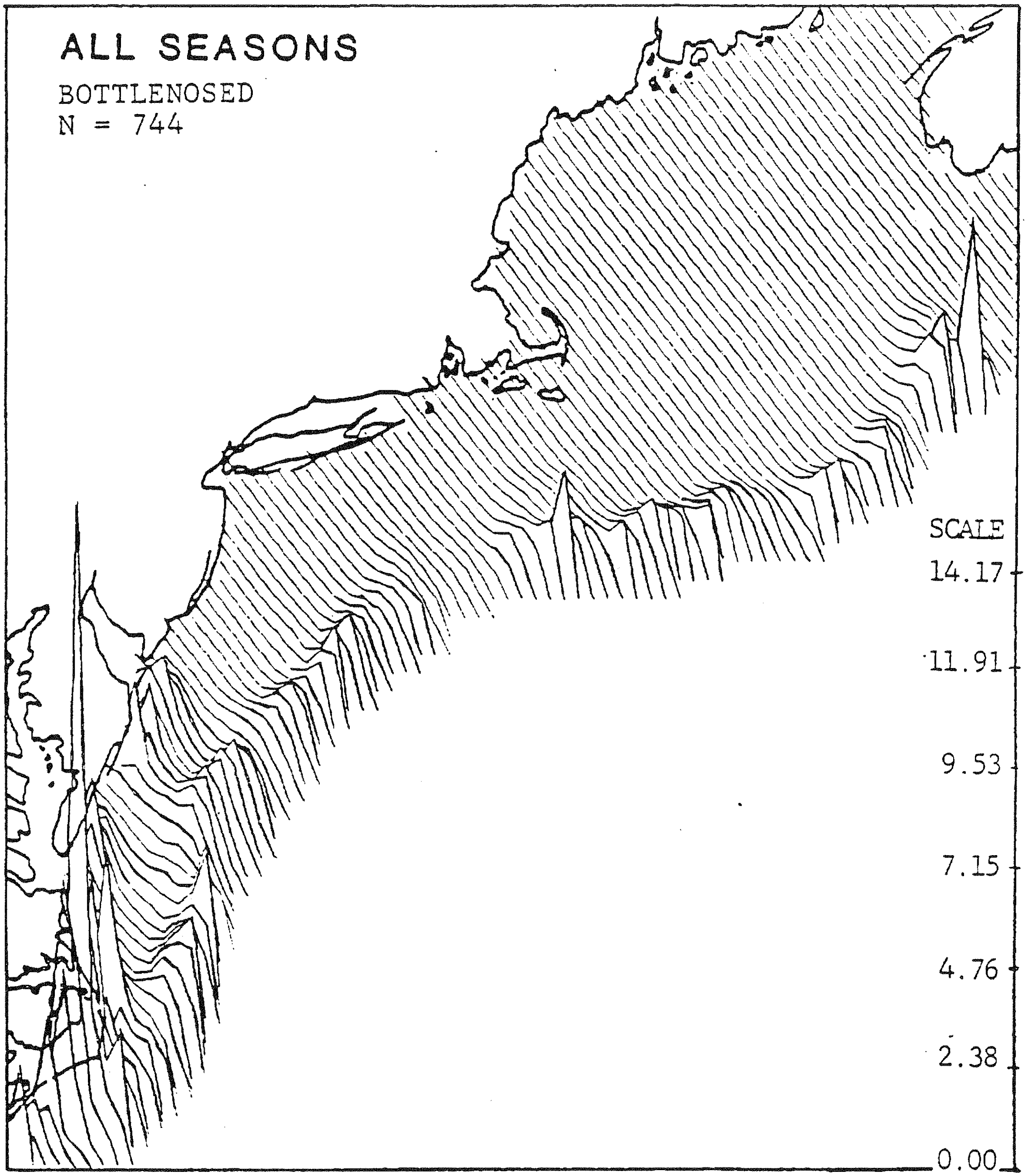

Figure 18b. The relative abundance of T. truncatus for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

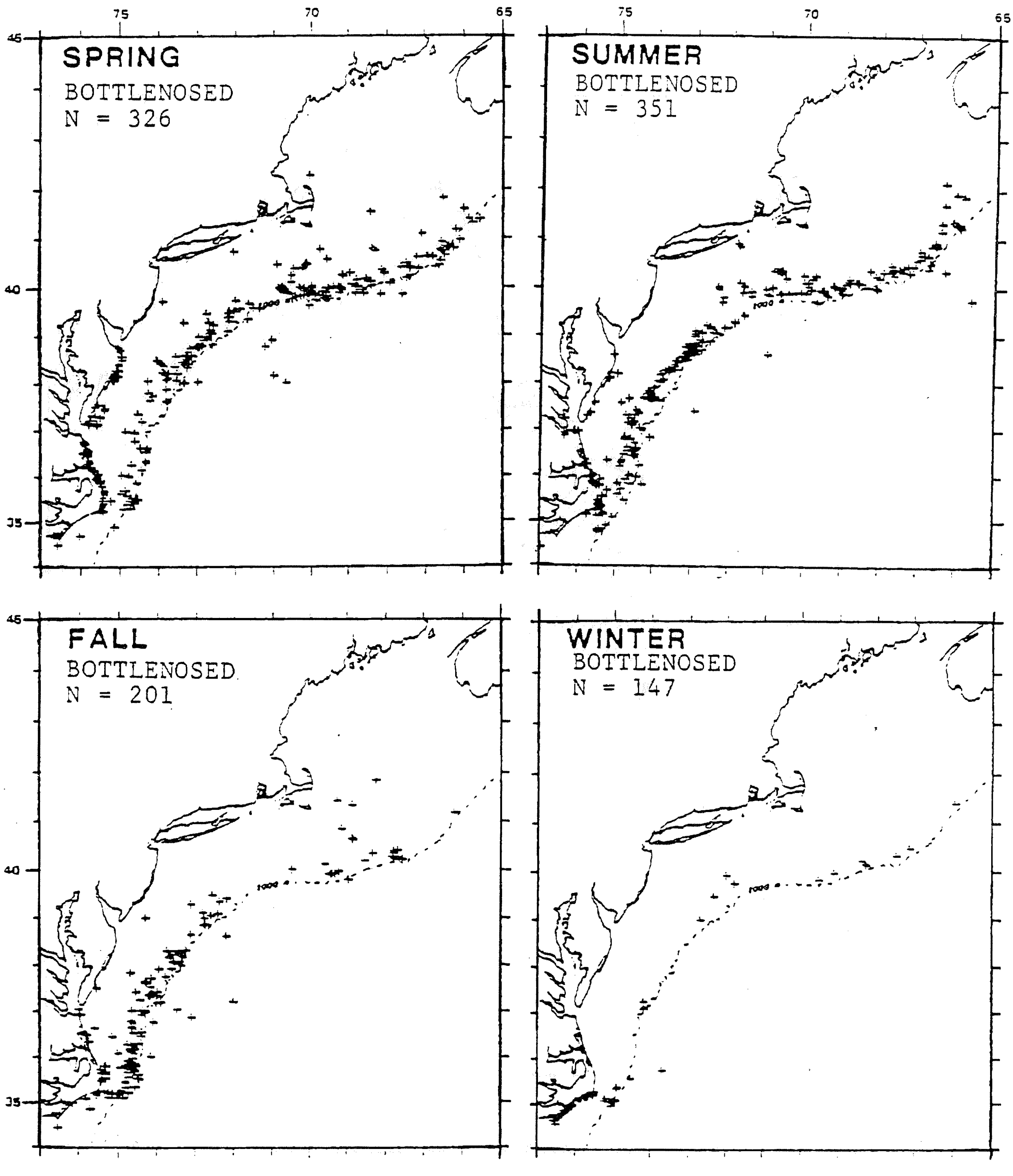

Figure 18c. The sighting distribution of T. truncatus by season.

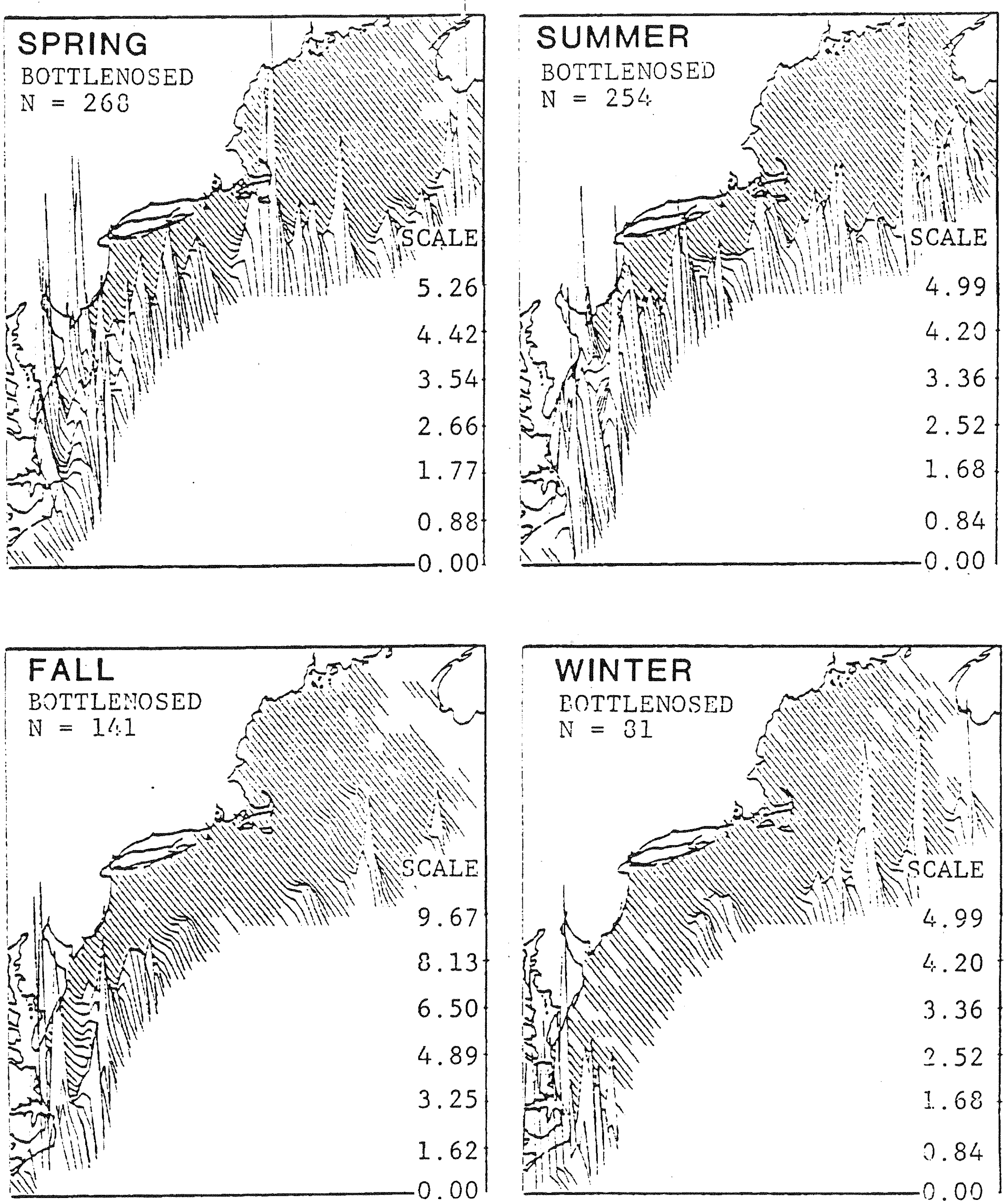

Figure 18d. The relative abundance of _T. truncatus_ by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

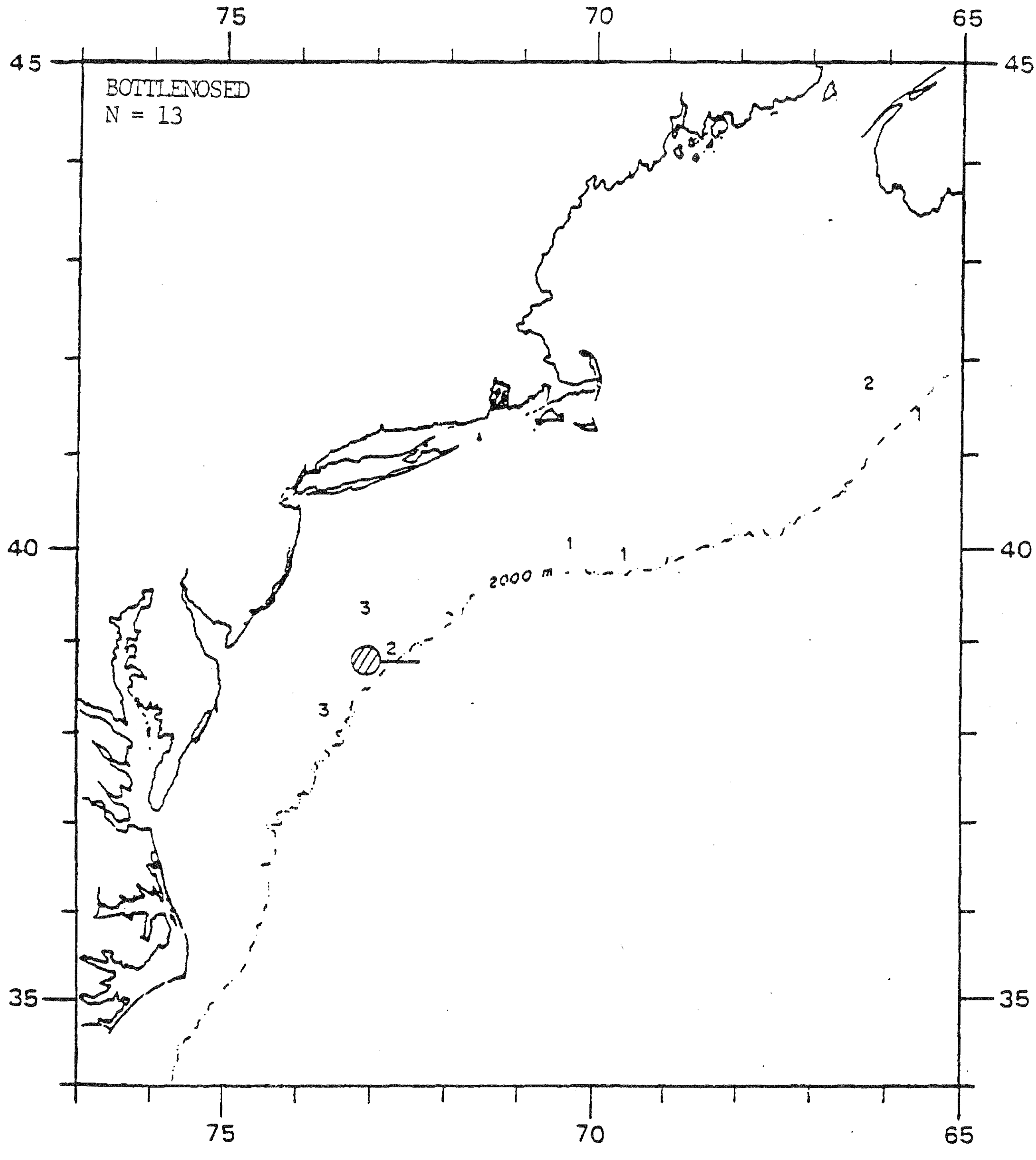

Figure 18e. Sightings of feeding or apparent feeding of T. truncatus. Single and widely separated observations are denoted by a number indicating the season in which the sighting occurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations were concentrated in an area, the area has been enclosed by a lined region and the seasons of included observations are shown on the adjoining line.

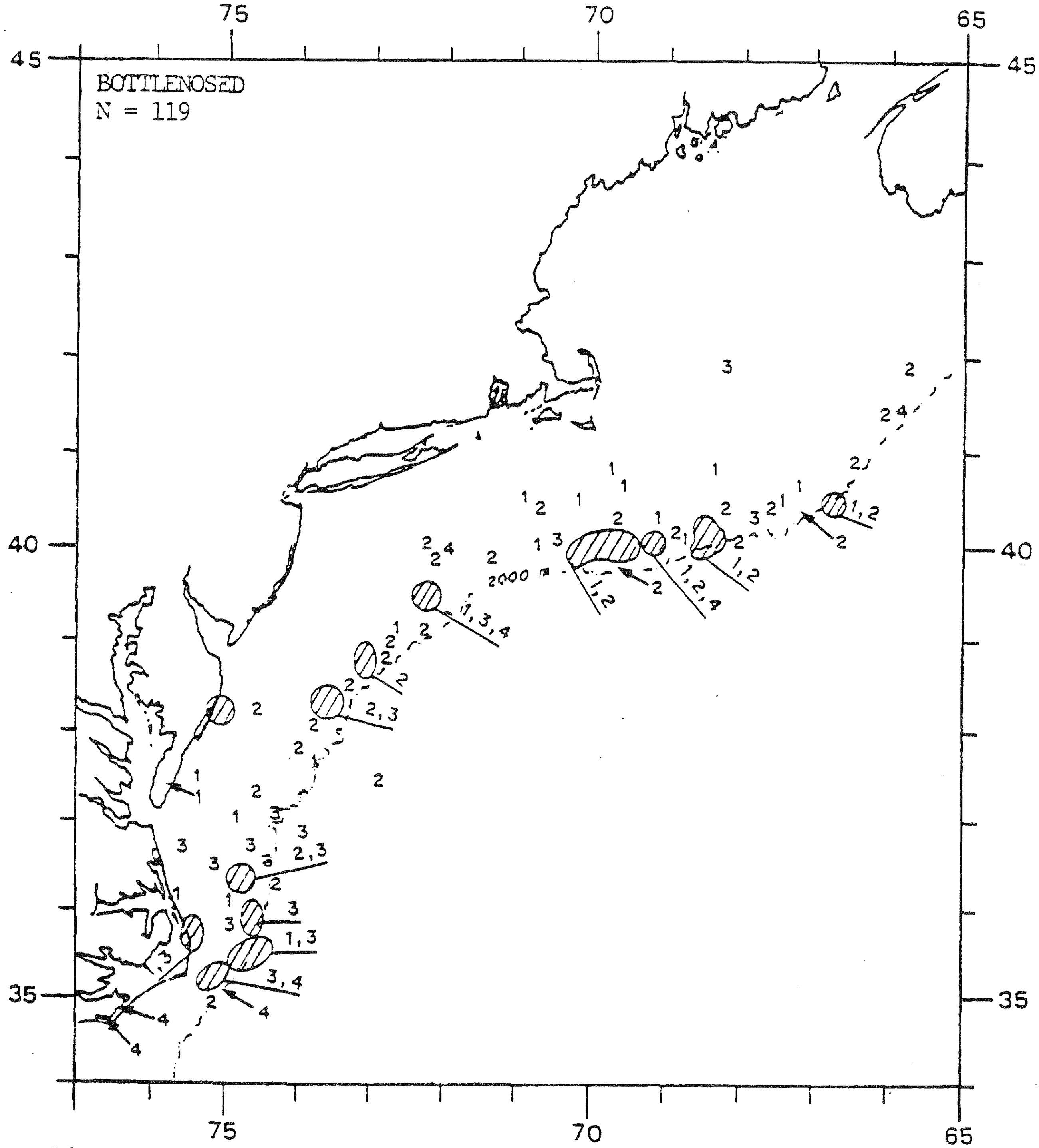

Figure 18f. Sightings of calves or juveniles of T. truncatus. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

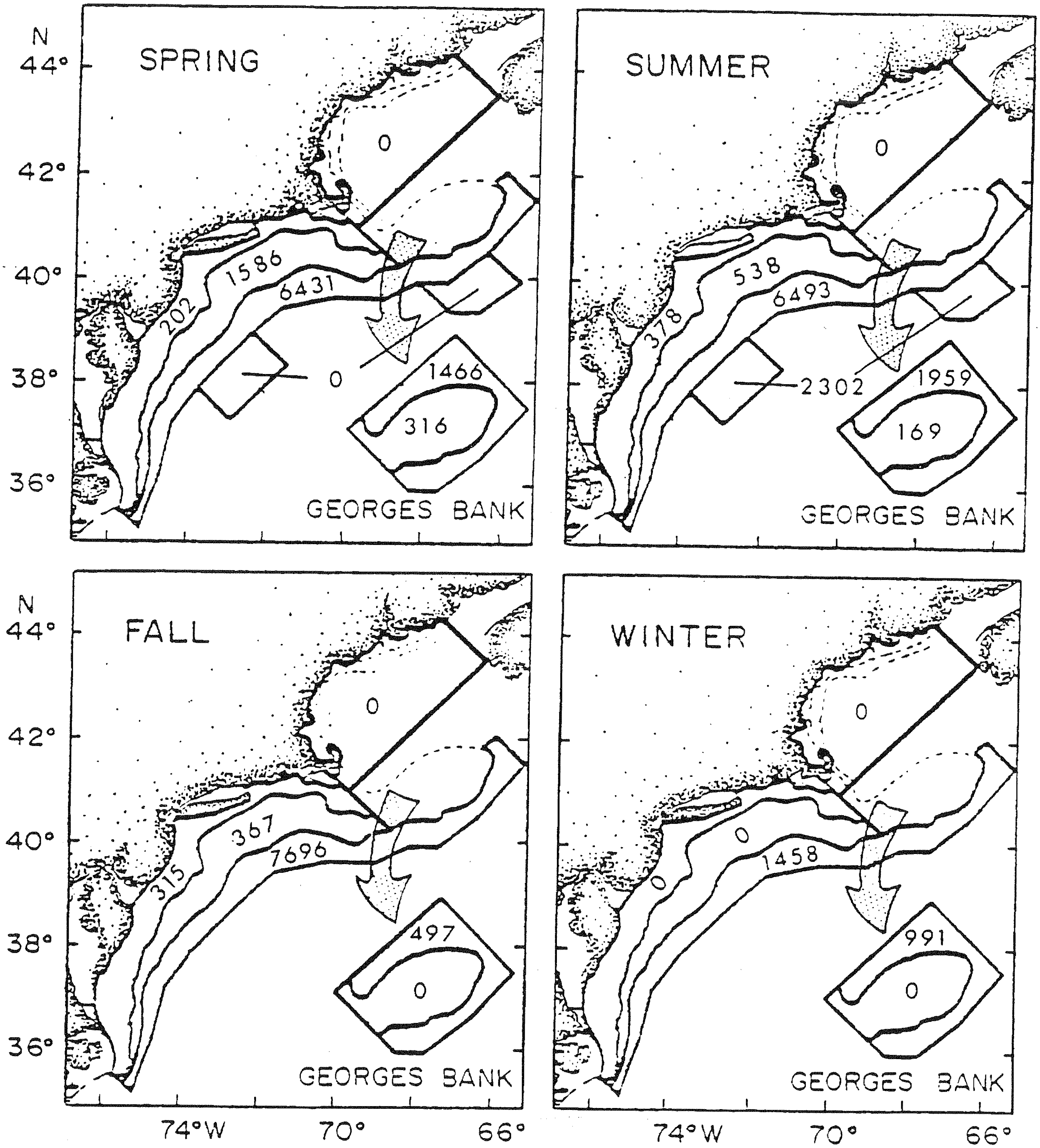

Figure 18g. Estimates of the number of individuals of T. truncatus by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 13. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for <u>Tursiops truncatus</u>.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
GEORGES BANK	2.41E-02	2.76E-02	7.67E-03	1.04E-02
	5.28E-03	7.87E-03	9.05E-04	1.89E-03
	1663	1905	530	716
	± 1661	± 2328	± 1595	± 1268
<50 FATHOMS	9.78E-03	5.21E-03	0.00E+00	0.00E+00
	1.46E-03	9.97E-04	0.00E+00	0.00E+00
	316	169	0	0
	± 636	± 589	± 0	± 0
>50 FATHOMS	4.00E-02	5.34E-02	1.35E-02	2.70E-02
	9.50E-03	1.58E-02	1.60E-03	4.92E-03
	1466	1959	497	991
	± 1778	± 2553	± 1820	± 1729
LEASE SALE 52	9.70E-02	1.03E-01	1.82E-02	2.03E-02
	2.39E-02	2.80E-02	1.67E-03	3.47E-03
	2706	2883	508	566
	± 2216	± 2820	± 1197	± 910
MID-ATLANTIC	4.59E-02	4.20E-02	3.64E-02	4.08E-03
	1.20E-02	9.31E-03	1.98E-02	9.76E-04
	6300	5768	4996	560
	± 3635	± 3599	± 5775	± 1085
NEAR SHORE	4.96E-03	9.27E-03	7.73E-03	0.00E+00
	8.68E-04	1.19E-03	1.21E-03	0.00E+00
	202	378	315	0
	± 520	± 723	± 787	± 0
MID-SHELF	3.03E-02	1.03E-02	7.00E-03	0.00E+00
	7.10E-03	1.41E-03	1.77E-03	0.00E+00
	1586	538	367	0
	± 1908	± 1009	± 1219	± 0
NEW YORK BIGHT	4.42E-02	2.77E-02	1.23E-02	6.30E-03
	1.27E-02	4.12E-03	2.94E-03	1.22E-03
	2741	1718	762	391
	± 2883	± 1765	± 1727	± 1045
SHELF EDGE	1.04E-01	1.05E-01	1.24E-01	2.35E-02
	2.76E-02	2.65E-02	7.15E-02	4.93E-03
	6431	6493	7696	1458
	± 4001	± 4170	± 10036	± 1885
CONTINENTAL SLOPE	0.00E+00	7.46E-02	.	.
	0.00E+00	1.03E-02	.	.
	0	2302	.	.
	± 0	± 28159	± .	± .
STUDY AREA OCS*	8603	8213	6909	1295
	± 4307	± 4524	± 7625	± 1633

*Study area OCS does not include the slope water regions.

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Lagenorhynchus acutus - White-sided dolphin

INTRODUCTION

1981 DATA. The 1981 data were consistent with the data from CETAP in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. *L. acutus* was the fourth most commonly sighted small whale in the study area. The 584 sightings of 31,276 individuals accounted for 14% of the small whale sightings, and 13% of the odontocete sightings. The total number of individuals was greater than that for any other species.

Individuals per Sighting. The average number of individuals per sighting was 54.3, the third largest for all odontocetes, and third largest for small whales. The mode was 6 with a range from 1 to 800.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *Lagenorhynchus acutus* is one of three odontocetes primarily inhabiting the continental shelf proper, shoreward of the 100 m depth contour (Figures 19 a-d). The sightings are distributed in the western Gulf of Maine, east and southeast of Cape Cod, and over Georges Bank during spring, summer, and fall. In winter the sightings are fewer, although the relative abundance data indicate that certain areas (Cape Cod, Gulf of Maine) still contain the species at abundance levels comparable to other seasons. However, these areas are smaller and less numerous than in other seasons, and the overall level of L. acutus in the study area in winter is decreased.

There were a few sightings of L. acutus south of 40°N. These sightings were in January, April, July, August, September, and December. The I.D. reliabilities ranged from "sure" to "probable" to "unsure." The present data are sufficient, however, to include the OCS south to a latitude of 37°N as certainly within the range of L.acutus, but beyond the area of most common inhabitance. These data extend the the distribution of L. acutus to about 300 n mi southwest of that given previously (Katona et al., 1978) and, in this regard, are consistent with the stranding data reported by Testaverde and Mead (1980).

Feeding. Sightings of white-sided dolphins feeding at the surface were a limited subset of the general sighting pattern. Whereas general sightings were found all along the Great South Channel/Jeffreys Ledge corridor and throughout the Gulf of Maine, feeding sightings were primarily along the 100 m contour as part of the Great South Channel/Jeffreys Ledge corridor (Fig. 19e). There were two sightings in the northern Gulf of Maine. Feeding sightings accounted for about 6% of the total sightings. Feeding sightings were made year round, but over 70% were in spring/summer, coincident with the increased effort at that time.

White-sided dolphins have been reported to feed on a variety of squid (Illex illecebrosus), herring, silver hake (Merluccius bilinearis) and other fishes (Geraci et al., 1976; Schevill, 1956; Katona et al., 1978b). In the present study white-sided dolphins were often seen in the presence of humpback and fin whales, and were probably feeding on sand lance on such occasions. In other areas of their range, e.g., Gulf of Maine, the white-sided dolphins undoubtedly feed, but they are probably feeding sub-surface on other fish and squid.

There were scattered general sightings of white-sided dolphins in Lease Area 42, and Proposed Area 52. There were no feeding sightings directly within any Lease Areas, but again, we suggest that since white-sided dolphins are seen in the Lease Areas, they must be feeding, probably sub-surface. In addition, the feeding area in the Great South Channel/Jeffreys Ledge corridor is directly to the northwest of areas 42 and 52.

Calves and Juveniles. During the three year survey period, 33 sightings of white-sided dolphin calves or juveniles were reported (see Figure 19f). The north-south range of calf sightings extended from the Great South Channel to the northern Gulf of Maine, and the east-west range extended from coastal waters to the eastern edge of the Gulf of Maine. No calves were found in the southern portion of the adult range which extended to Norfolk Canyon. During the spring, calves were concentrated (13 sightings) near the Great South Channel and Cape Cod, while the summer sightings (12) were found mostly within the Gulf of Maine. Most fall sightings were found in an intermediate zone between the Gulf of Maine and Cape Cod. One winter sighting was seen along the northern edge of Georges Bank.

This distribution pattern suggests that calves may migrate north during the spring and summer, and return south during the fall.

Sergeant et al. (1980) reported that white-sided dolphins are probably born between May and August.

Calves were found among adult groups ranging in size from 2 to 400 animals.

No calves were found within BLM Lease Sale Areas 40, 42, 49, or 59, or within Proposed Lease Sale Area 52.

Areas. In three years of sampling, *L. acutus* was only reported once from the Mid-Atlantic Lease Sale Areas (11 April 1979,15+ individuals, I.D. reliability = "unsure", extreme western portion of 40 and 49). Based on these data, *L. acutus* is either extremely rare or completely absent from Mid-Atlantic Lease Sale Areas 40, 49, and 59. In the North Atlantic, *L. acutus* occurs infrequently in Lease Sale 42 and Proposed Lease Sale 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 14 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 19g. The peak average abundance estimate for *L. acutus* in the Study Area was 36281 (+/19027) and occurred in the spring. The maximum point estimate of abundance for this species was 46344 (+/- 592776) in sampling block A during June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 46436 (no CI) in sampling block A, stratum z, in June 1979. The high variability in these estimates is principally due to the variability in the pod sizes sampled for this genus.

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature for L. acutus sightings was 12.8, the second coolest for all odontocetes and second coolest for all small whales; the mode was 8.0 with a range from 1.3 to 23.8. Ninety percent of all sightings fall within a moderately wide water temperature range (6.0 to 19.9°C). This reflects the moderately wide latitudinal range of most L. acutus sightings from New Jersey to the Bay of Fundy.

Depth (m). The average depth for L. acutus sightings was 165m, the third shallowest for all odontocetes and third shallowest for small whale species. The mode was 82 with a range from 12 to 2432m. Ninety percent of these sightings were made over a narrow depth range (38 to 271m). This corresponds with the sighting distribution of L. acutus; sightings were concentrated in coastal waters especially near Cape Cod, and in shallow waters within the Gulf of Maine.

BEHAVIOR

Associations. Whitesided dolphins were observed as a component of a multispecies aggregation in 25% of sightings of L.acutus. Similar to the other common odontocete species inhabiting the Gulf of Maine, P.phocoena, 92% of these associations involved one or more of at least 4 species of large whales including, in decreasing order of occurrence, B.physalus, M.novaeangliae, and equal occurrences with E.glacialis and B.acutorostrata (refer to Table 30, for details). Sightings involving some combination of fin whales, humpback whales, and whitesided dolphins accounted for 63% of all multispecies sightings reported for *L.acutus*. These associations were frequently observed within areas of feeding activity, probably accounting for the frequency with which seabird species were recorded as present. *L.acutus* were also often observed bowriding ahead of whales during multispecies sightings. Beyond the above mentioned species, whitesided dolphins were only rarely observed in proximity to another odontocete species (refer to Table 30). In 7 of 17 such occurrences, *P.phocoena* was the species observed with *L.acutus*. The frequent association of *L.acutus* with *Globicephala* spp. reported by Sergeant and Fisher (1957) in waters around Newfoundland was only observed twice in the CETAP study area, presumably due to differing patterns of distribution.

Migration and Movement. The decreased abundance levels for *L. acutus* during winter suggest an emigration from the study area in late fall. The other areas involved in the migration are at present unknown. While Geraci et al. (1976) stated that the species is usually found offshore over the continental slope, this is not generally supported by the CETAP data. While an inshore/offshore movement may be involved, the question remains unresolved at this time.

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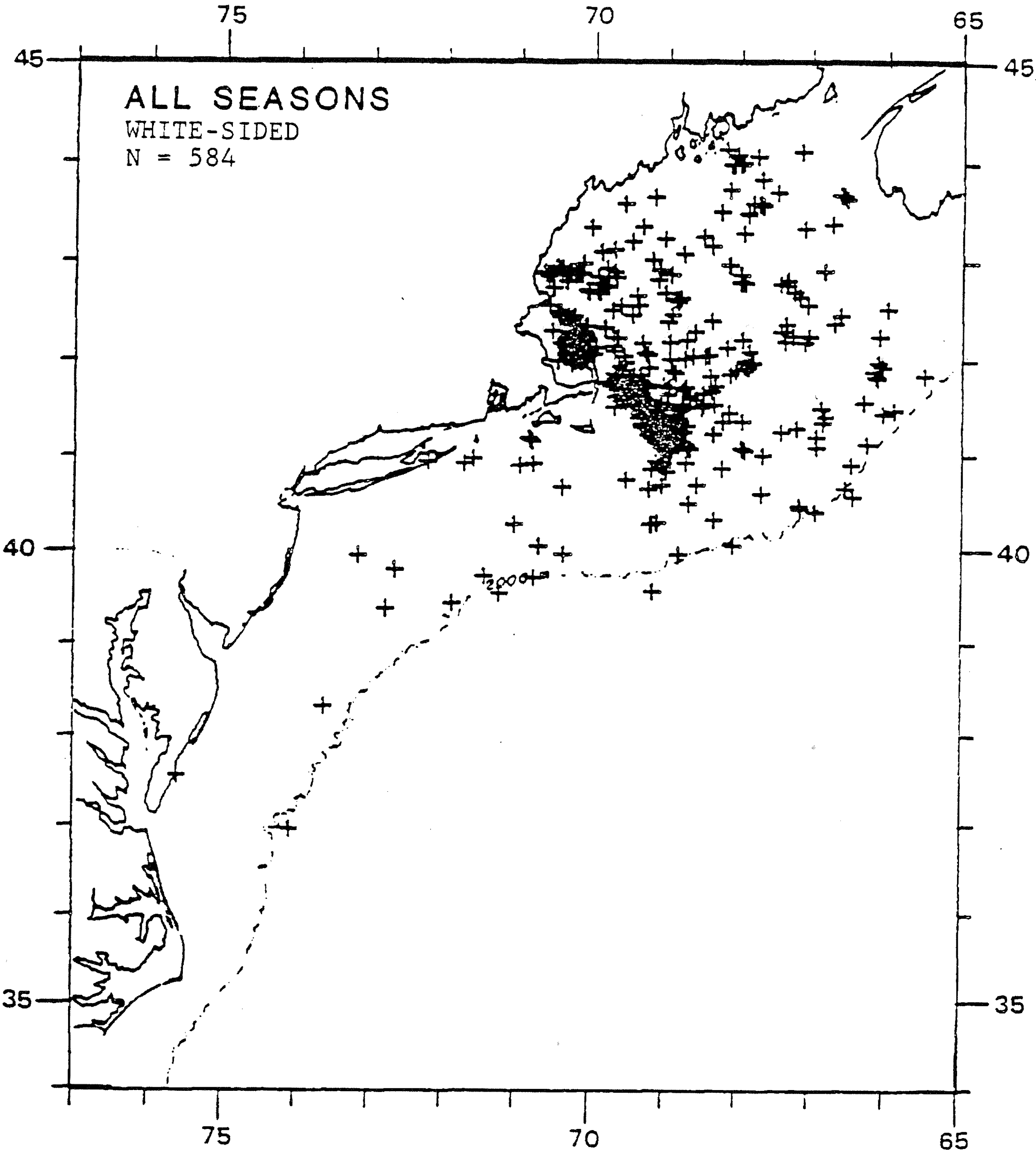

Figure 19a. All sightings of the white-sided dolphin, Lagenorhynchus acutus, for the 39 month period -- 1 November 1978 through 28 January 1982.

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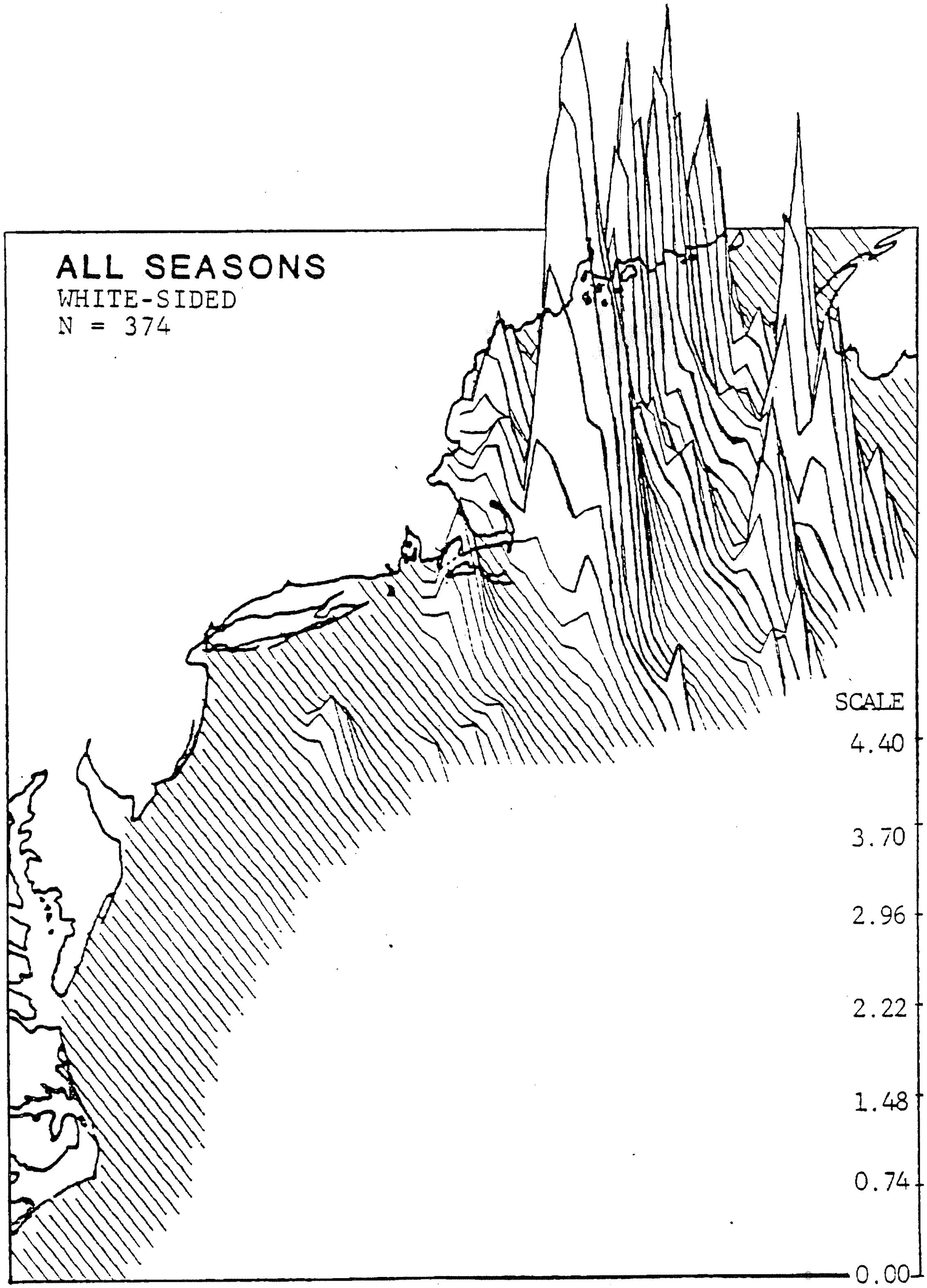

Figure 19b. The relative abundance of L. acutus for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

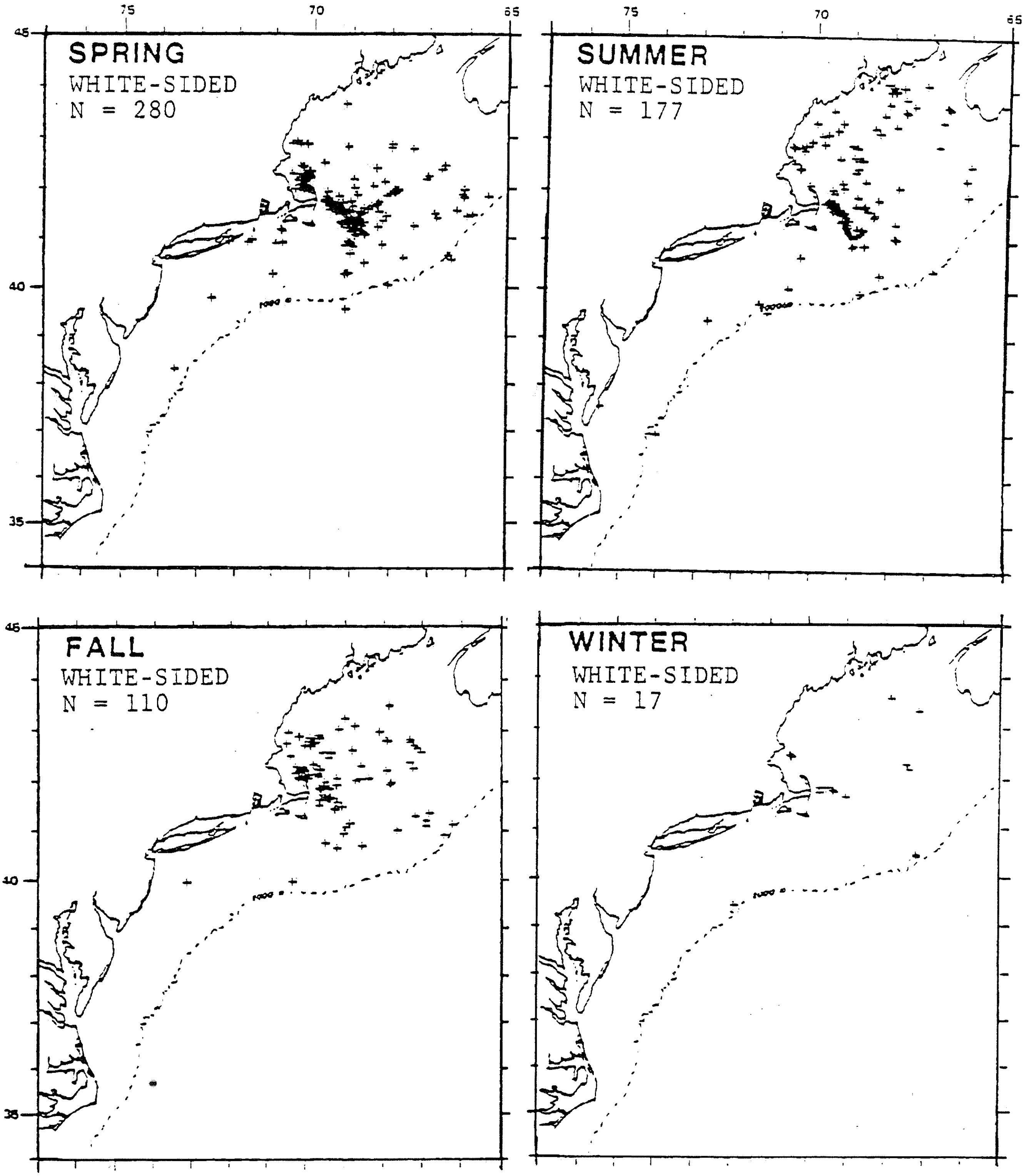

Figure 19c. The sighting distribution of L. acutus by season.

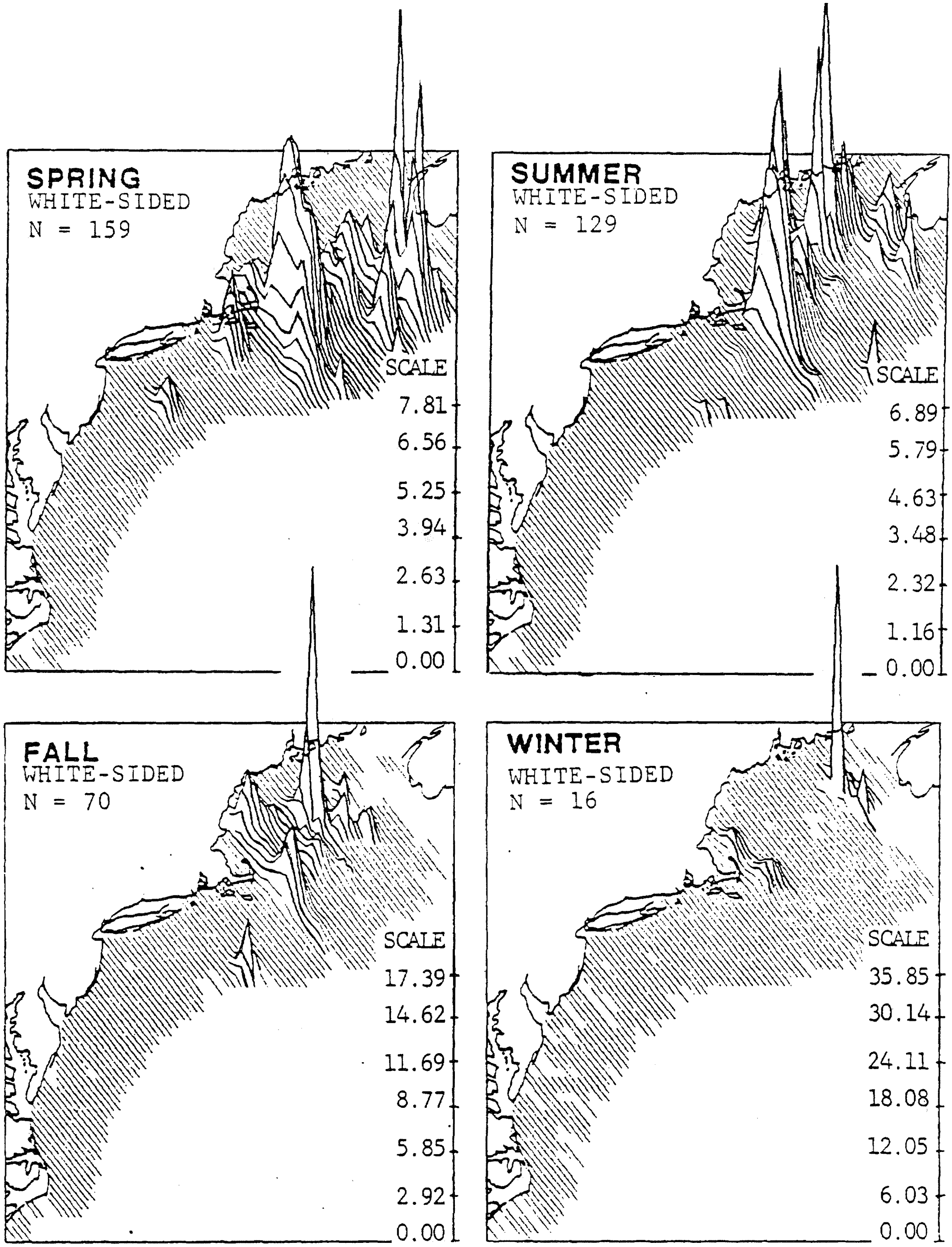

Figure 19d. The relative abundance of L. acutus by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

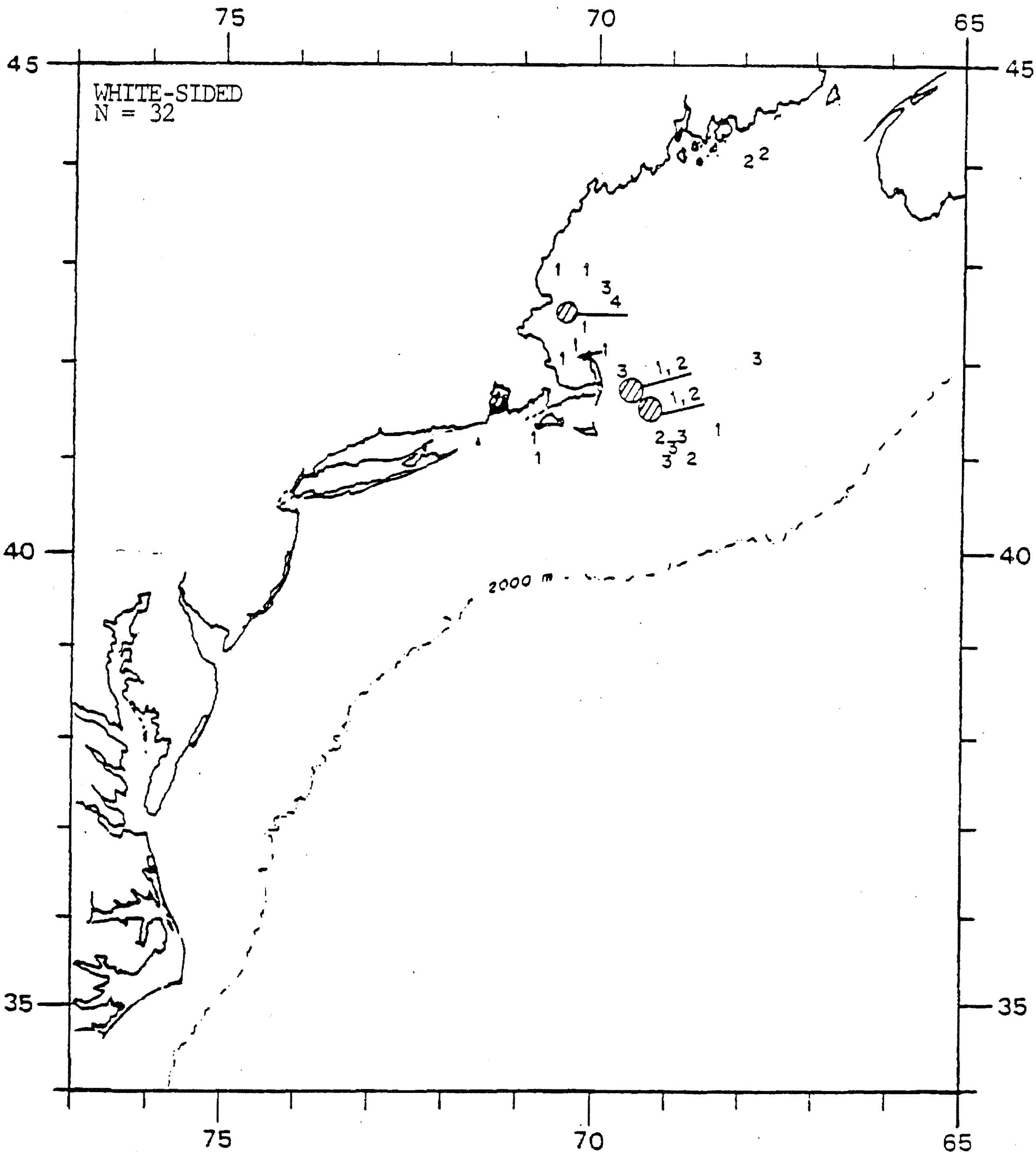

Figure 19e. Sightings of feeding or apparent feeding of L. acutus. Single and widely separated observations are denoted by a number indicating the season in which the sighting occurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations were concentrated in an area, the area has been enclosed by a lined region and the seasons of included observations are shown on the adjoining line.

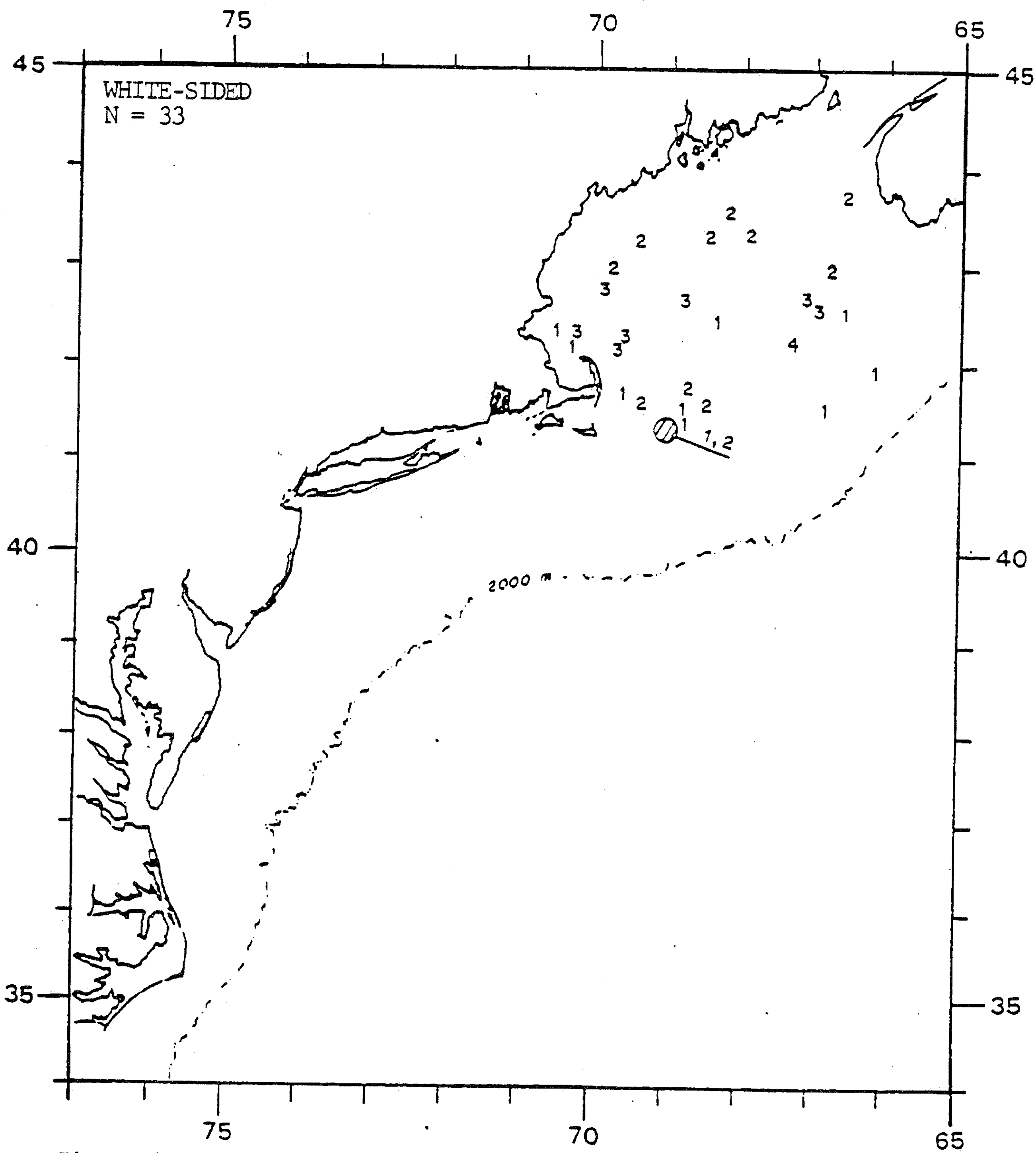

Figure 19f. Sightings of calves or juveniles of L. acutus. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

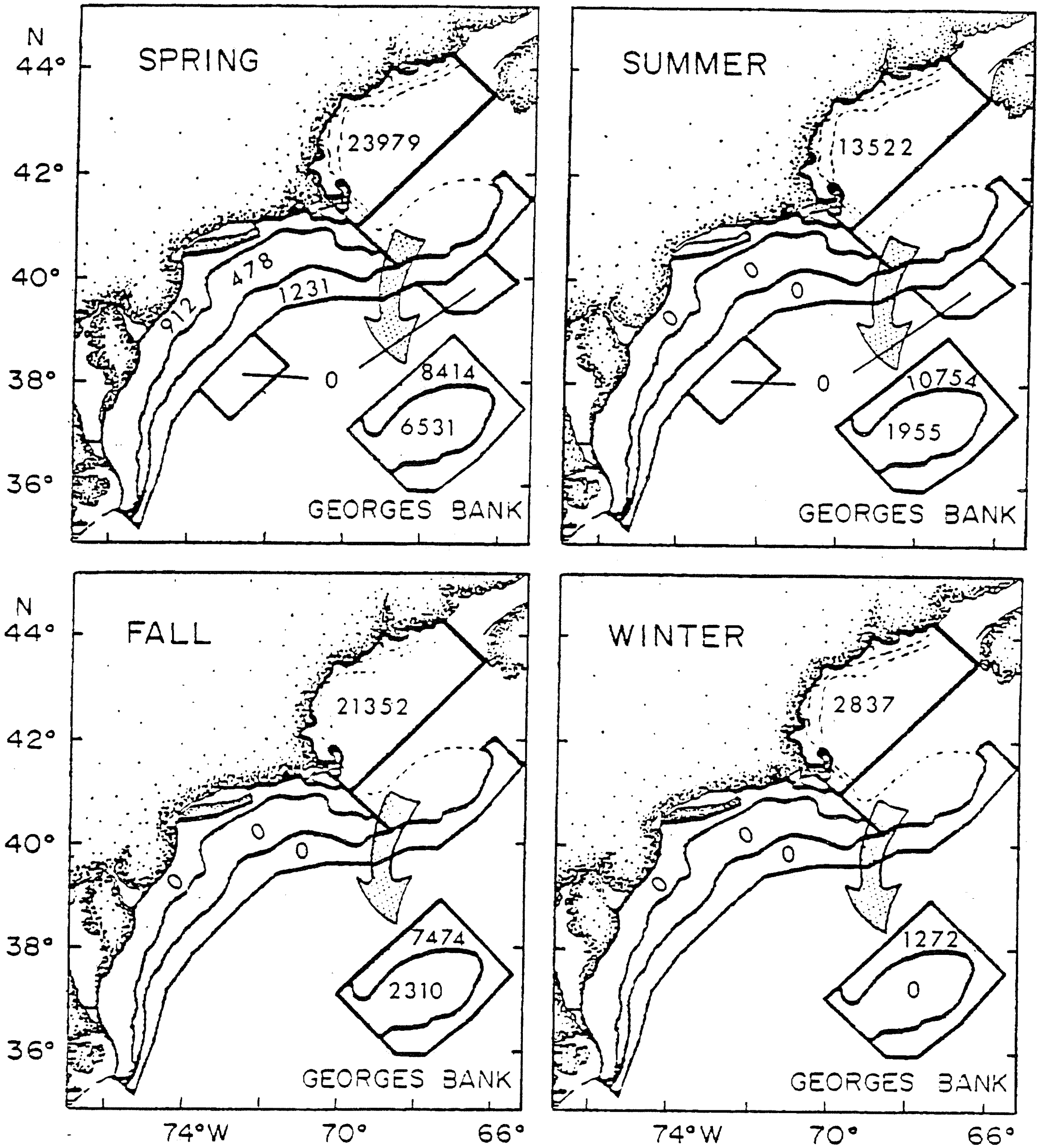

Figure 19g. Estimates of the number of individuals of L. acutus by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 14. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for <u>Lagenorhynchus</u> <u>acutus</u>.

REGION	SEASON: SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	3.33E-01	1.88E-01	2.96E-01	3.94E-02
	1.13E-01	1.42E-01	4.51E-01	3.33E-02
	23979	13522	21352	2837
	± 10242	± 12378	± 26809	± 5429
GEORGES BANK	2.15E-01	1.69E-01	1.46E-01	1.33E-02
	4.56E-01	4.82E-01	1.83E-01	6.75E-03
	14838	11634	10104	920
	± 15433	± 18225	± 22696	± 2395
<50 FATHOMS	2.02E-01	6.05E-02	7.14E-02	0.00E+00
	3.01E-01	4.13E-02	6.18E-02	0.00E+00
	6531	1955	2310	0
	± 9123	± 3795	± 12783	± 0
>50 FATHOMS	2.29E-01	2.93E-01	2.04E-01	3.47E-02
	6.27E-01	9.90E-01	2.76E-01	1.76E-02
	8414	10754	7474	1272
	± 14442	± 20217	± 23918	± 3266
LEASE SALE 52	3.16E-02	0.00E+00	0.00E+00	0.00E+00
	1.18E-02	0.00E+00	0.00E+00	0.00E+00
	881	0	0	0
	± 1555	± 0	± 0	± 0
MID-ATLANTIC	1.19E-02	0.00E+00	0.00E+00	0.00E+00
	1.13E-02	0.00E+00	0.00E+00	0.00E+00
	1637	0	0	0
	± 3526	± 0	± 0	± 0
NEAR SHORE	2.24E-02	0.00E+00	0.00E+00	0.00E+00
	3.33E-02	0.00E+00	0.00E+00	0.00E+00
	912	0	0	0
	± 3219	± 0	± 0	± 0
MID-SHELF	9.13E-03	0.00E+00	0.00E+00	0.00E+00
	3.41E-03	0.00E+00	0.00E+00	0.00E+00
	478	0	0	0
	± 1322	± 0	± 0	± 0
NEW YORK BIGHT	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
SHELF EDGE	1.98E-02	0.00E+00	0.00E+00	0.00E+00
	6.43E-03	0.00E+00	0.00E+00	0.00E+00
	1231	0	0	0
	± 1931	± 0	± 0	± 0
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	36281	23452	23085	3240
	± 19027	± 21638	± 23197	± 4902

*Study area OCS does not include the slope water regions.

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L. albirostris - white-beaked dolphin

INTRODUCTION

1981 Data. There was only a single sighting of *L. albirostris* in 1981. This is most likely due to the discontinuation of the shipboard platform-of-opportunity program at the end of 1980. The sighting was just south of Block Island and extends the possible range of the species westward by about 50 n mi. Both these points are discussed in the cumulative results for all years given below.

Number of Sightings. *L. albirostris* was an infrequently sighted small whale in the study area. The 33 sightings of 523 individuals accounted for 1% of the small whale sightings and 1% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 15.8, a relatively small value compared to other odontocetes and small whale species; the mode was 1 with a range from 1 to 200.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *L. albirostris* has a distribution restricted in both time and space. All but four sightings were in the area immediately surrounding Cape Cod and east to northeast of Cape Ann (Figures 20 a-b). Of the 33 total sightings of the species, 23 were in spring, 7 in summer, 2 in fall, and 1 in winter.

The sightings in Vineyard Sound (off Falmouth, 30 March 1979, 4 individuals) and in Buzzards Bay (2 n mi west of Nomans Land, 6 June 1979, 5 individuals) are of interest since cetaceans are only rarely sighted in these areas. Both sightings were by experienced observers, and were assigned I.D. reliabilities of "sure."

The three shelf-edge sightings shown in Figure 20a are exceptions to the general pattern. The two more northern sightings were both given I.D. reliabilities of "probable." The third sighting, 6 May 1979, northeast of Cape Hatteras, was reported with an I.D. reliability of "sure." However, the sighting was opportunistic and there is no information recorded as to the observer's experience in field identification of marine mammals. Therefore, the possibility of a range, occasional or regular, south and west of Cape Cod is recognized, but future confirmation will be required.

L. albirostris is regarded as the more northerly of the two species of *Lagenorhynchus* in the western North Atlantic, and is apparently far more numerous from Canada northward to Greenland (Katona et al., 1978; Leatherwood et al., 1976). The sightings recorded by CETAP around Cape Cod and through the western Gulf of Maine may represent individuals along the southern margin of the species' normal range. As with a number of other species, it is noteworthy that 29 of 33 sightings were made from shipboard platforms.

Feeding. There were no observations of surface feeding white-beaked dolphins in the current study.

White-beaked dolphins feed heavily on squid in more northerly Canadian waters, as evidenced by their common name "squidhounds" in Newfoundland (Leatherwood et al, 1976). They also feed opportunistically on cod, herring, and capelin (Van Bree and Nigssen, 1964). The white-beaked dolphins in the current study area, observed primarily in the Cape Cod Bay/Jeffreys Ledge region, were most likely feeding on a variety of fish, possibly including sand lance. The limited distribution of whitebeaked dolphins in the Cape Cod area, a region which is a considerable distance from their more common northerly range, is probably a result of favorable opportunistic feeding on the part of the dolphins. Hence, it is likely that the white-beaked dolphins were sub-surface feeding in the Cape Cod Bay/Jeffreys Ledge region.

Calves and Juveniles. No calves or juveniles of *L. albirostris* were reported during the study period.

Areas. To date, no sightings of *L.albirostris* have been reported from any of the Lease Sale Areas in the Mid-Atlantic (40, 49, 59). In the North Atlantic, no sightings have been reported from Lease Sale 42. In Proposed Lease Sale 52, there has been only a single sighting (26 February 1979, 20 individuals, I.D. reliability = "probable," water depth = 91 m) from over southwestern Georges Bank.

POPULATION ESTIMATES AND STATUS

Population estimates. An abundance estimate of 573 (+/- 792) for 1980 Right Whale Survey Block 2 in May 1980 was the only population estimate for the white-beaked dolphin.

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature for *L. albirostris* sightings was 7.2°C, the coolest for all odontocetes and all small whales. The mode was 7.5 with a range from 6.3 to 17.5°C. This would be expected considering that most sightings were found north of Cape Cod.

Depth (m). The average depth for *L. albirostris* sightings was 102m, the shallowest for all odontocetes and all small whales. The mode was 13 with a range from 13 to 748m. Ninety percent of these sightings fell within a depth range of 13 to 748m. Most sightings were concentrated in shallow, coastal waters near Cape Cod and along Stellwagen bank.

BEHAVIOR

Associations. Only 3 of 33 sightings resulted in observations of white-beaked dolphins in proximity to another cetacean species. Single occurrences with *M.novaeangliae*, *B.acutorostrata*, *D.delphis*, *P.phocoena*, and *L.acutus*, and three occurrences with *B.physalus* comprise the species breakdown for these multispecies sightings. An additional association has been noted by Sergeant and Fisher (1957) upon observing a school of 12 white-beaked dolphins close to but not amongst a herd of pilot whales, _Globicephala_ sp., in eastern Canadian waters.

Migration and Movement. The abundance of spring sightings may indicate an influx to the study area at this time and an outflow in the fall.

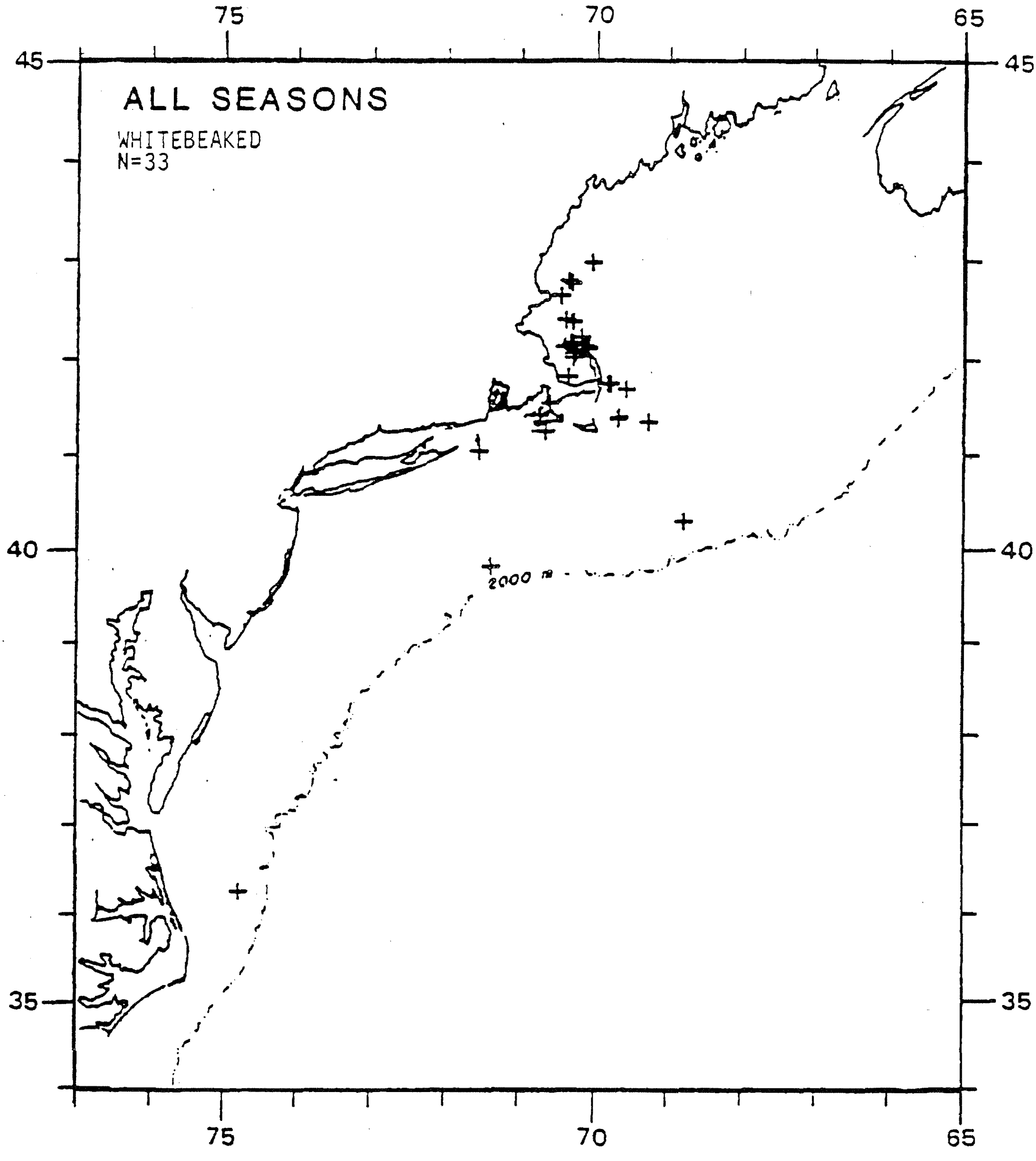

Figure 20a. All sightings of the white-beaked dolphin, Lagenorhynchus albirostris, for the 39 month period -- 1 November 1978 through 28 January 1982.

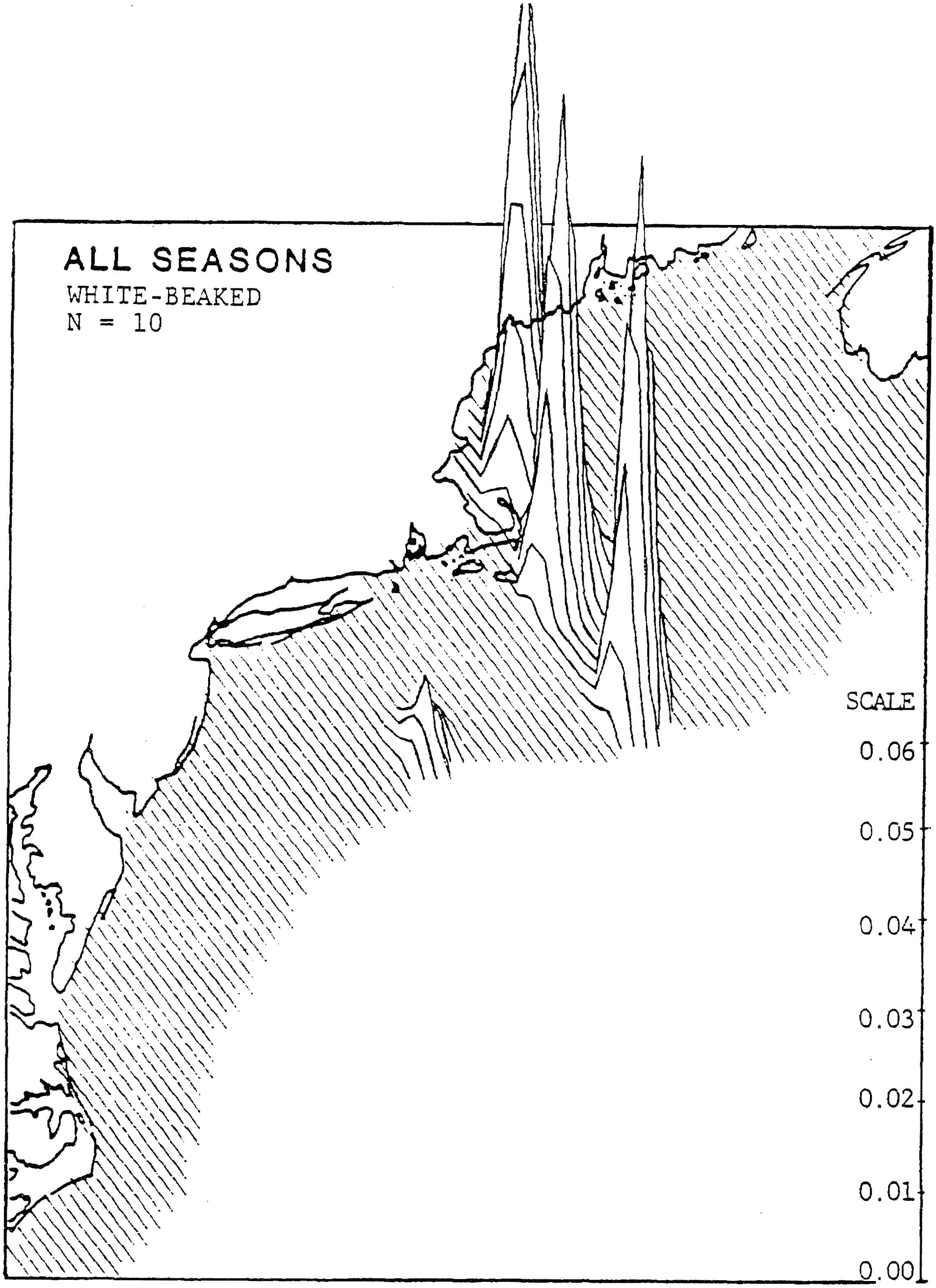

Figure 20b. The relative abundance of L. albirostris for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

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Globicephala spp. - Pilot whale

INTRODUCTION

Taxonomy and Identification. As has been the practice in the past, CETAP continues to identify the pilot whale to the generic level only, as *G. melaena* (northern or Atlantic pilot whale) and *G. macrorhynchus* (southern or short-finned pilot whale) are virtually indistinguishable in the field.

1981 Data. The 1981 data were consistent with the results of CETAP studies in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. Pilot whales, *Globicephala* spp., were the third most commonly sighted small whales in the study area. The 619 sightings of 12,438 individuals accounted for 15% of the small whale sightings and 13% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 20.1, the fifth largest group size for all odontocetes and all small whales. The mode was 10 with a range from 1 to 500.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. Pilot whale distribution is complicated by the unavoidable practice of considering collectively the two species which occur in the study area. *G. macrorhynchus*, mainly a southern or tropical species, has the northern limit of its range at about 38°N= the longitude of the Delmarva Peninsula, while *G. melaena*, the northern species, has the southern limit of its range at about 35°30'N =the latitude of Cape Hatteras (Leatherwood et al., 1976; Katona et al., 1978). The area of overlap in the ranges may be occupied simultaneously or alternately by the two species.

The distribution of *Globicephala* spp. generally follows the shelf edge throughout the study area, and is centered about the 1000 m depth contour (Figures 21a-d). The distribution, however, is broadly defined and extends inshore as well as offshore. Several sightings were reported seaward of the 2000 m contour. These data are consistent with those reported by Brown (1961) and suggest that pilot whale distribution includes some or all of the deep ocean. The species was also commonly sighted over the shelf and inshore of the 100 m depth contour. This occurred almost throughout the study area= in the Mid-Atlantic Bight, south of New England, over Georges Bank, and in the Gulf of Maine.

The relative abundance data (Figure 21d) indicate that pilot whales are present in many sections of the study area at similar levels the year-round. This seems to be particularly true for the southern margin of Georges Bank. It is not the case for the on-shelf areas of Georges Bank or the Gulf of Maine, or for a large section of the Mid-Atlantic Bight, where winter sightings are almost completely absent. This suggests that while some areas remain inhabited throughout the year, there is an overall reduction in areas occupied and total number of individuals within the study area in winter.

Feeding. Sightings of surface feeding pilot whales were infrequent, noted in only 1.5% of the total general sightings. These few surface feeding sightings were primarily scattered along the continental shelf break and through the Great South Channel (Fig. 21c). These areas, along with Georges Bank are the regions of most pilot whale sightings. Pilot whales were seen feeding primarily in spring and summer. This can probably be attributed to greater sighting effort at those times.

Pilot whales feed primarily on squid, but also feed on gadoids (Mercer, 1975). Thus, pilot whales are primarily sub-surface feeders, a fact which accounts for the low percentage of feeding observations. Therefore, the general sighting distribution may also be an indicator of feeding areas.

All of the Lease Areas were often frequented with pilot whales (Fig. 21a). Realizing that pilot whales may be feeding sub-surface in virtually all areas where they occur, particularly those rich productive waters along the shelf break, it is likely that all the Lease Areas are important feeding grounds for pilot whales.

Calves and Juveniles. During the three year survey period, 143 sightings of pilot whale calves or juveniles were reported (see Figure 21f). The distribution of these sightings paralleled the distribution found for adult whales. Calves were found from Cape Hatteras to the Gulf of Maine, mostly along the edge of the continental shelf. Calves were seen throughout this range during both the spring and summer seasons, but the frequency of sightings decreased from 67 in spring to 41 in summer. The 30 calf sightings reported during the fall seemed to be divided into 2 separate populations: the first group was concentrated on the shelf edge east of Cape Hatteras; the second group was more diffusely distributed in waters between New Jersey and the Gulf of Maine. During the winter, calves were seen on 7 occasions along the shelf edge east of New Jersey.

Since G. melaena (northern species) and G. macrorhynchus (southern species) were both represented in this account, it is not surprising that calf sightings were found in both the southern and northern extremes of the CETAP survey area. The observed separation of calves into two groups during the fall may reflect the separation of the northern and southern pilot whale species at that time. The sightings of calves as far north as the Gulf of Maine were not unexpected, since Kraus and Prescott (1981) reported G. melaena calves in the Bay of Fundy during August. Sergeant (1962) suggested that G. melaena calves are probably born from May to November, with a peak in August.

Pilot whale calves were found among adult groups typically ranging in size from 15 to 60 animals. The smallest group size reported was 3, and the largest was 500.

Numerous calf sightings were found within BLM Lease Sale Areas 40, 42, 49, and 59, and within Proposed Lease Sale Area 52, during all seasons.

Areas. Pilot whales occur commonly and widespread throughout Mid-Atlantic Lease Sale Areas 40, 49, and 59. Exceptions to this statement are the absence of sightings in the extreme northwest portions of 40 and 49 in all seasons, and the absence of sightings in the southern portion of all Mid-Atlantic areas in winter. In the North Atlantic, pilot whales similarly occur commonly and widespread in both 42 and Proposed 52. The single exception is the absence of sightings in 42 in winter.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 15 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 21g. The peak average estimate of abundance of pilot whales (both *Globicephala melaena* and *G. macrorhynchus*) in the study area was 12391 (+/- 18625) and occurred during fall. Correspondingly, the peak average estimate of abundance for this genus in waters defined as Shelf Edge was 13008 (+/- 24703) during the fall. The maximum point estimate of abundance for this genus was 12023 (+/- 34075) in sampling block C during August 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 9714 (+/- 29831) in sampling block N, stratum z, in August 1979.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 303 sightings of this species. The average water temperature for *Globicephala* spp. sightings was 15.3°C, a relatively cool value compared to those for other odontocete species. The mode was 10.0 with a range from 6.0 to 28.2°C. Ninety percent of all sightings were found in a wide range of water temperatures (8.1 to 24.0°C). These data may be explained by the wide latitudinal range of pilot whale sightings (Cape Hatteras to the Gulf of Maine).

Depth (m). The average depth for *Globicephala* spp. sightings was 821m. The mode was 91, with a range from 15 to 5121m. Ninety percent of these sightings were made over a wide depth range (46 to 2377). Since most pilot whale sightings were found along the shelf edge, a wide depth range would be expected.

BEHAVIOR

Associations. Pilot whales were observed near one or more of at least 6 species of large whale and 6 species of small whale in 25% of sightings of pilot whales. Eighty-four percent of these sightings occurred with only one other species present. The single most common association was between *Globicephala* and *Tursiops* and accounted for 51% of all *Globicephala* associations. Pilot whale/bottlenose dolphin associations have been observed and reported for almost 100 years beginning with Muller (1884), and more recently by Cadenat (1947, as cited in Brown 1961) and Norris and Prescott (1961). The latter authors suggest that this association is not a casual one and hypothesize that this "social parasitism" has to do with the relative advantage a species obtains by associating themselves with other species that are presumed to be more efficient at locating food. Frequently during these associations, calves or juveniles were reported for either or both species. Sergeant and Fisher (1957) report occasionally observing intermixed herds of *Globicephala* and *L.acutus*, presumably feeding on squid, in inshore waters of Newfoundland. These same species were reported together on only 2 occasions within the CETAP study area probably due to the different distributional ranges of the two species in these waters, However, associations involving *Globicephala* spp. and a dolphin species accounted for 85% of pilot whale associations. These associations, along with the occasional reports of *Globicephala* and the six large whale species regularly occurring in the CETAP study area are detailed in Table 30.

Migration and Movement. The relative abundance data in Figure 21d indicate a general contraction of areas inhabited and total numbers of individuals present in the winter season. This suggests a general movement offshore and/or southward in winter. This is consistent with the findings summarized by Katona et al. (1978) for *G. melaena*. The present data suggest that *G. macrorhynchus* may likewise undergo a similar wintertime shift in range.

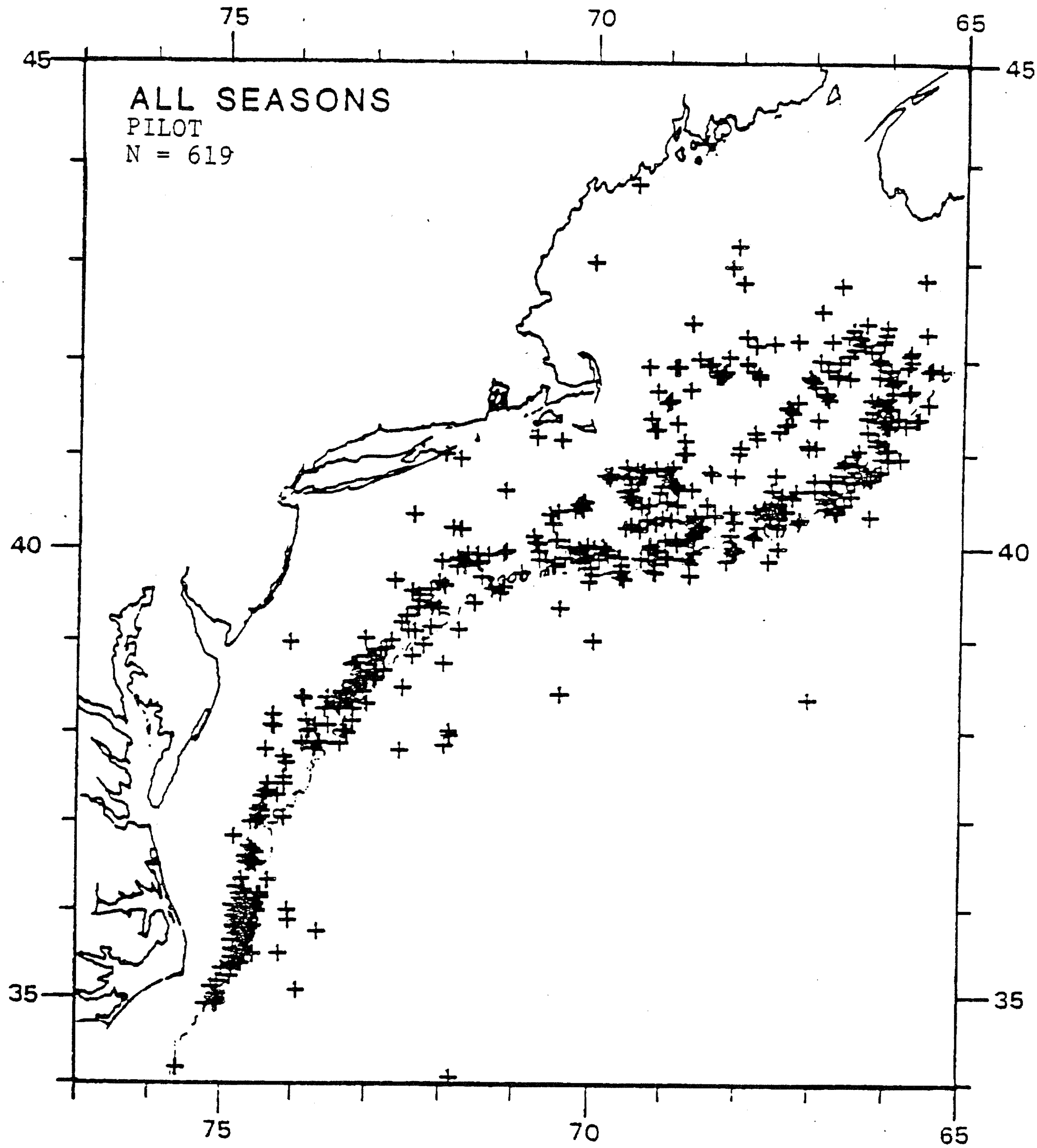

Figure 21a. All sightings of the pilot whale, Globicephala spp., for the 39 month period -- 1 November 1978 through 28 January 1982.

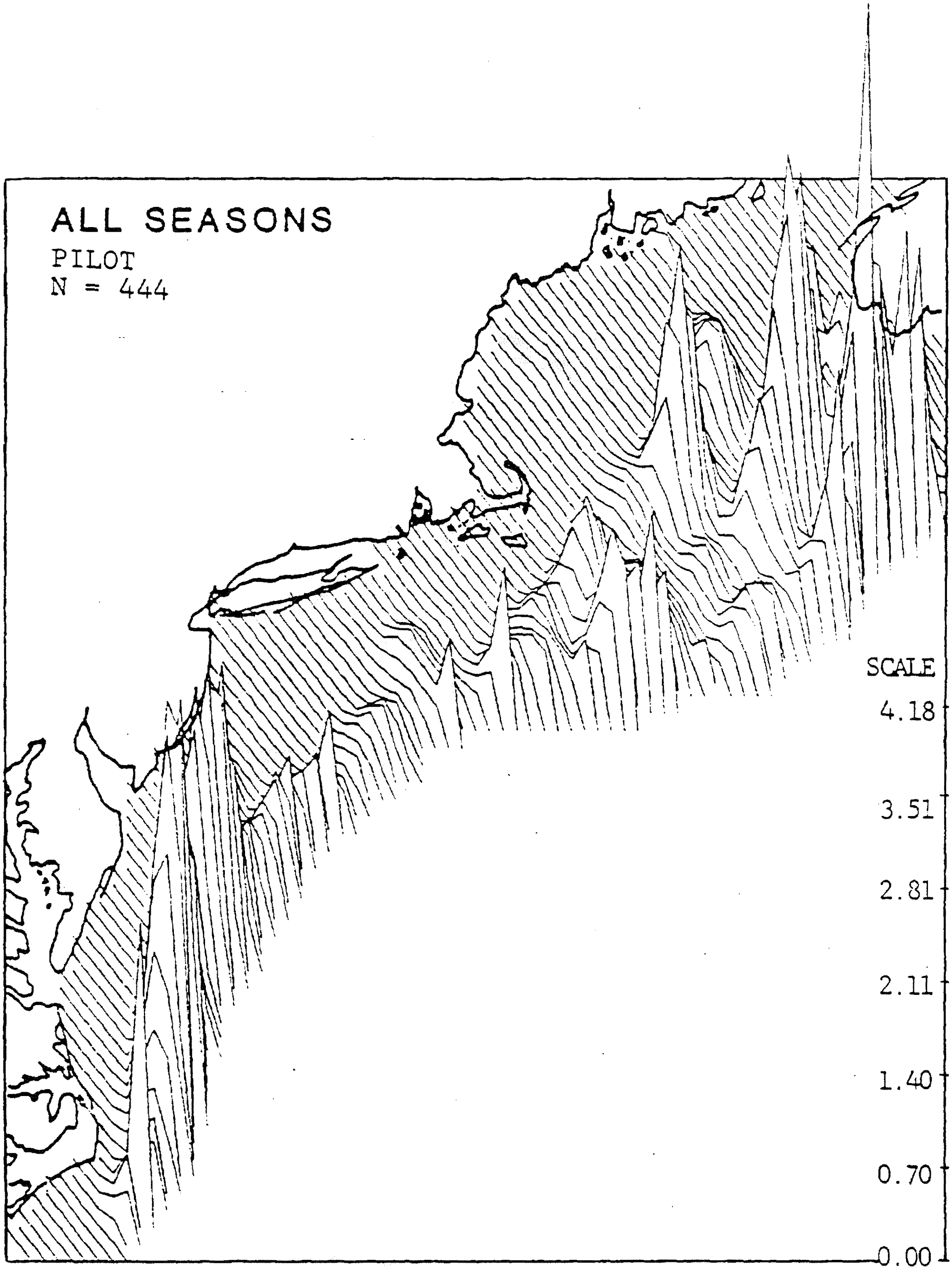

Figure 21b. The relative abundance of Globicephala spp. for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

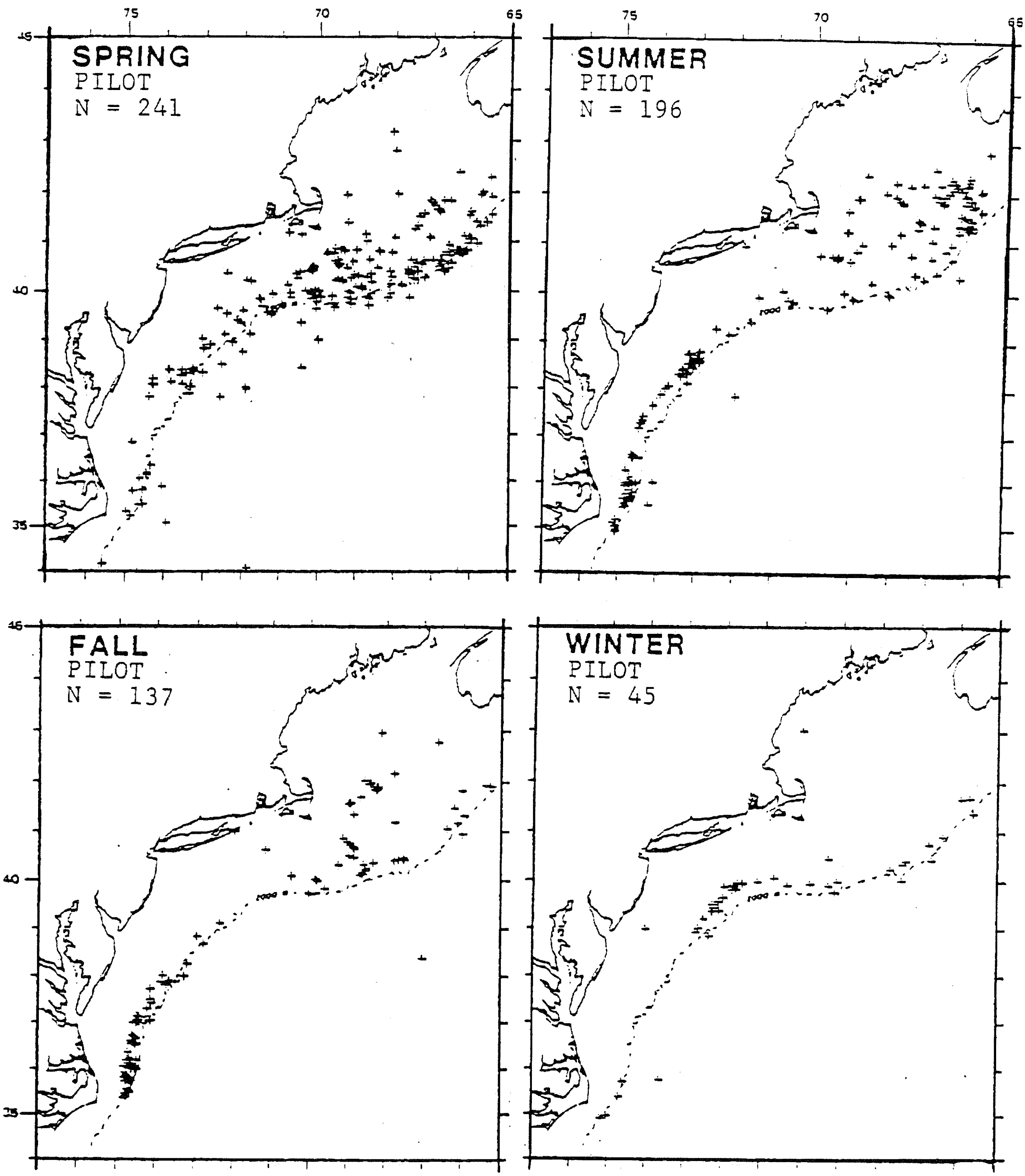

Figure 21c. The sighting distribution of <u>Globicephala</u> spp. by season.

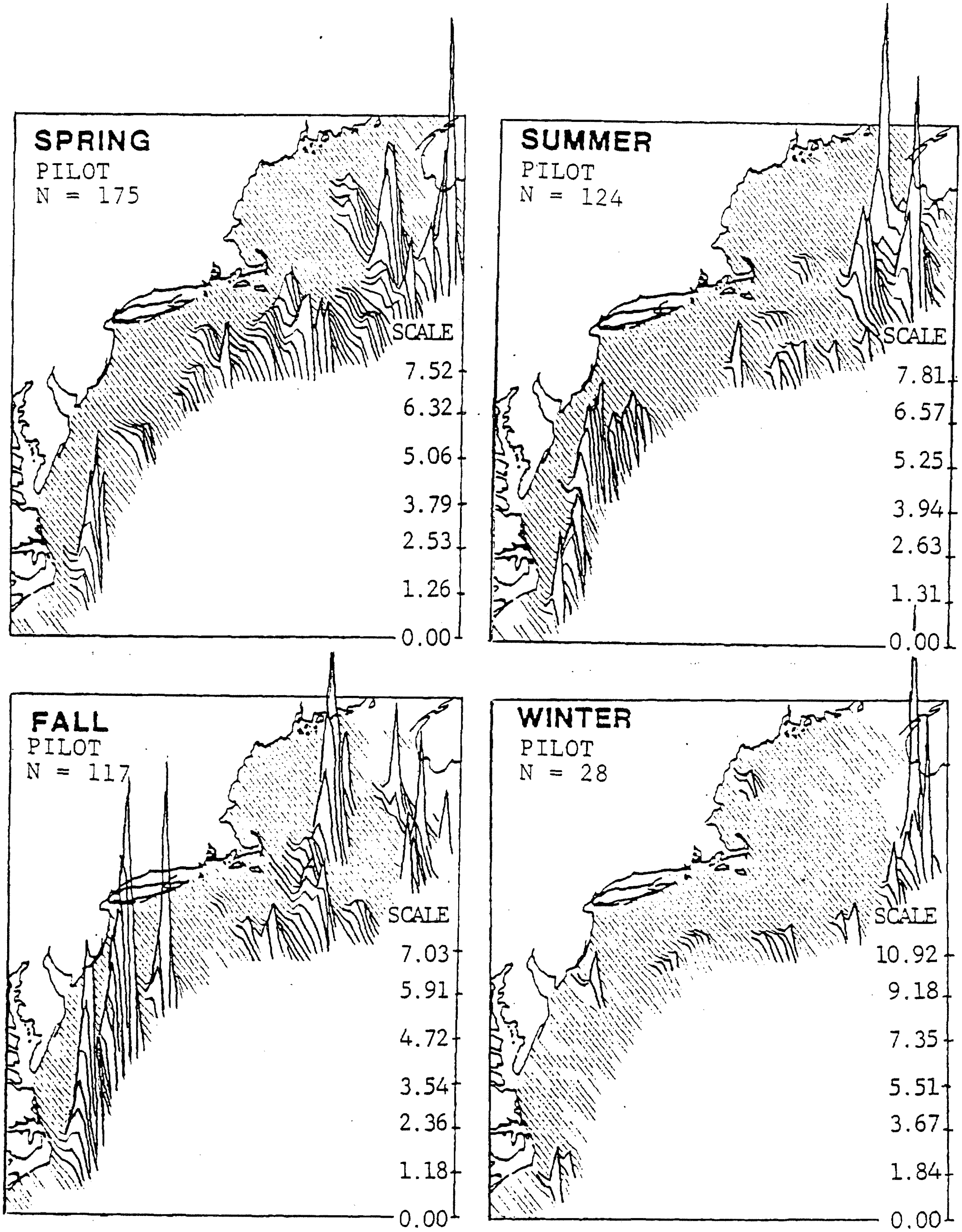

Figure 21d. The relative abundance of *Globicephala* spp. by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

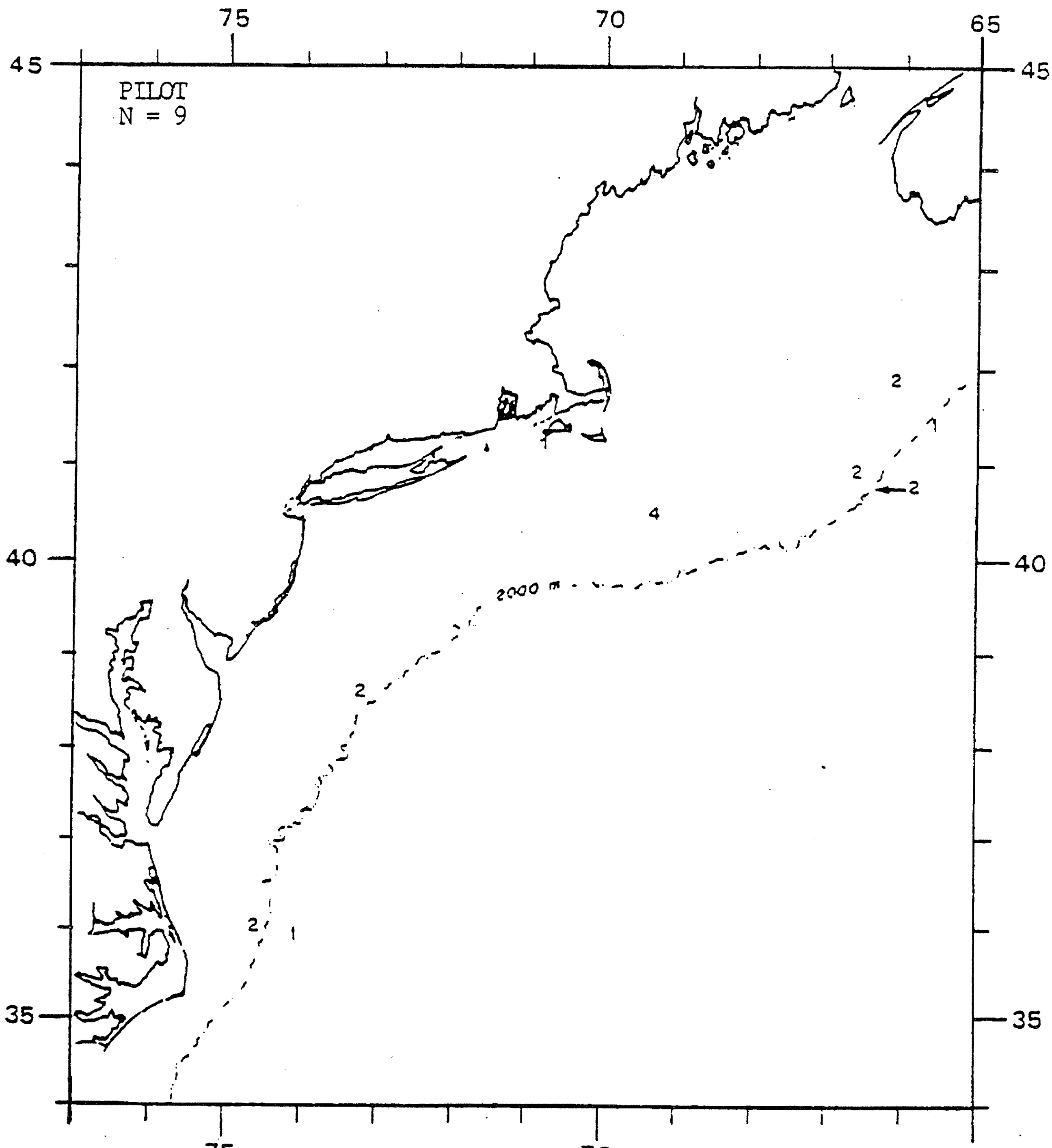

Figure 21e. Locations of sightings of feeding or apparent feeding of <u>Globicephala</u> spp. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

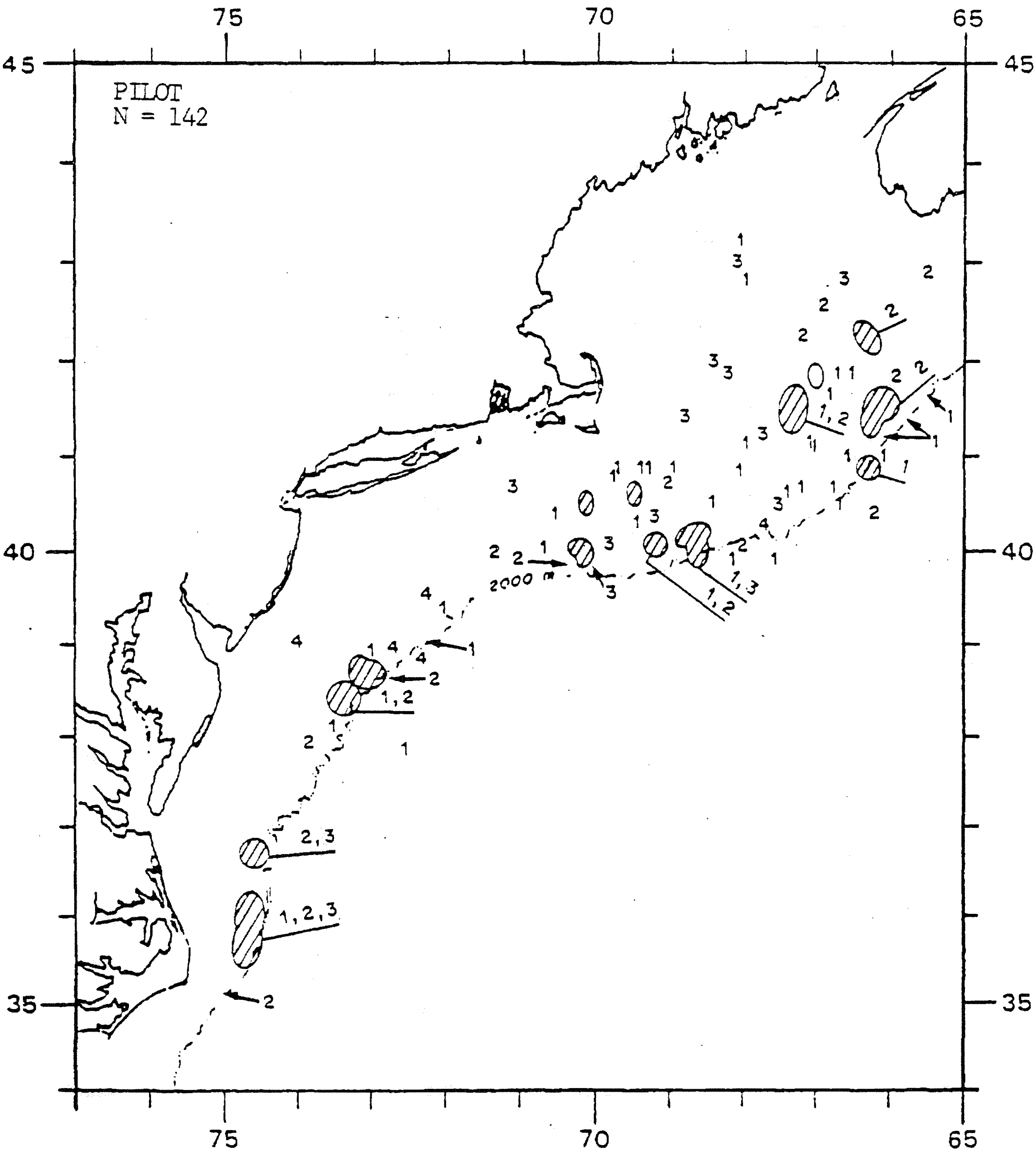

Figure 21f. Sightings of calves or juveniles of Globicephala spp. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

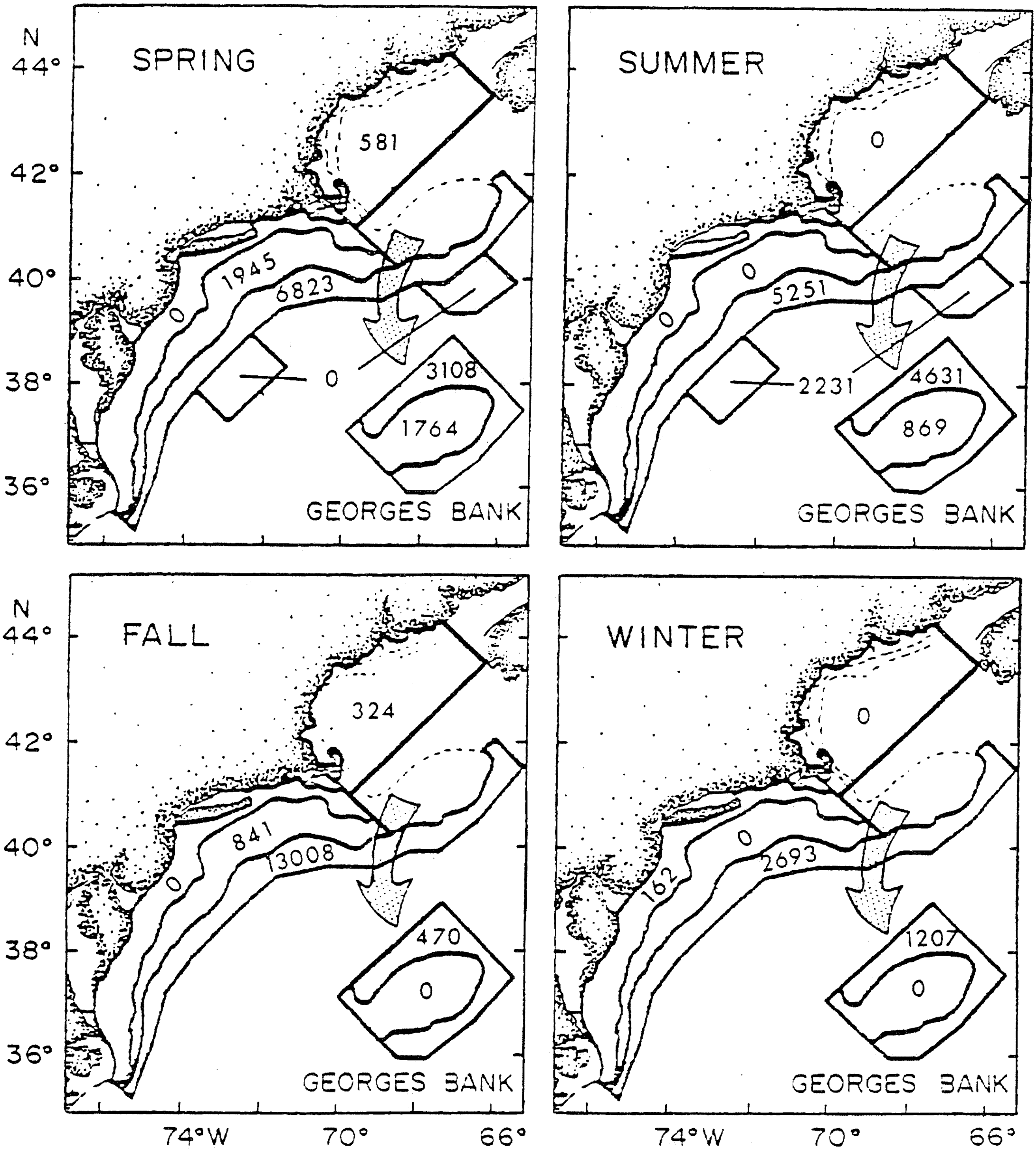

Figure 21g. Estimates of the number of individuals of Globicephala spp. by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 15. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Globicephala* spp.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	8.05E-03	0.00E+00	4.50E-03	0.00E+00
	1.70E-03	0.00E+00	6.80E-04	0.00E+00
	581	0	324	0
	± 1254	± 0	± 1041	± 0
GEORGES BANK	6.89E-02	7.30E-02	7.26E-03	1.26E-02
	5.15E-02	1.25E-01	1.22E-03	6.94E-03
	4754	5041	501	872
	± 5190	± 9281	± 1850	± 2428
<50 FATHOMS	5.46E-02	2.69E-02	0.00E+00	0.00E+00
	3.43E-02	2.13E-02	0.00E+00	0.00E+00
	1764	869	0	0
	± 3080	± 2723	± 0	± 0
>50 FATHOMS	8.47E-02	1.26E-01	1.28E-02	3.29E-02
	7.06E-02	2.45E-01	2.15E-03	1.81E-02
	3108	4631	470	1207
	± 4846	± 10048	± 2110	± 3312
LEASE SALE 52	1.04E-01	4.06E-02	5.39E-02	5.57E-02
	6.42E-02	4.22E-02	4.38E-02	2.83E-02
	2887	1133	1502	1554
	± 3634	± 3462	± 6126	± 2599
MID-ATLANTIC	3.93E-02	2.93E-02	6.51E-02	1.14E-02
	2.60E-02	4.03E-02	1.19E-01	4.39E-03
	5388	4023	8932	1566
	± 5338	± 7492	± 14141	± 2301
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	3.97E-03
	0.00E+00	0.00E+00	0.00E+00	1.21E-03
	0	0	0	162
	± 0	± 0	± 0	± 645
MID-SHELF	3.72E-02	0.00E+00	1.61E-02	0.00E+00
	2.33E-02	0.00E+00	8.09E-03	0.00E+00
	1945	0	841	0
	± 3459	± 0	± 2608	± 0
NEW YORK BIGHT	2.98E-02	3.48E-02	7.61E-03	8.24E-03
	2.42E-02	5.77E-02	2.11E-03	2.48E-03
	1849	2156	472	511
	± 3981	± 6606	± 1465	± 1490
SHELF EDGE	1.10E-01	8.46E-02	2.09E-01	4.34E-02
	8.29E-02	1.01E-01	4.33E-01	2.02E-02
	6823	5251	13008	2693
	± 6934	± 8138	± 24703	± 3817
CONTINENTAL SLOPE	0.00E+00	7.23E-02	.	.
	0.00E+00	3.90E-02	.	.
	0	2231	.	.
	± 0	± 54749	± .	± .
STUDY AREA OCS*	11417	9808	12391	2565
	± 8168	± 12688	± 18625	± 3315

*Study area OCS does not include the slope water regions.

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Grampus griseus - Grampus or Risso's dolphin

INTRODUCTION

1981 Data. The 1981 data were consistent with the results of 1979 and 1980 CETAP studies. The sections below describe the cumulative results.

Number of Sightings. *G. griseus* was the fifth most commonly sighted small whale in the study area. The 478 sightings of 8,244 individuals accounted for 11% of the small whale sightings and 10% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average group size was 17.2. The mode was 1, with a range from 1 to 400.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *Grampus griseus* sightings occurred along the shelf-edge from Cape Hatteras northward to Georges Bank during spring, summer, and fall (Fig. 22c-d). In winter the range is contracted southward to the Mid-Atlantic Bight. In general, the population of grampus in the study area is centered along the shelf edge in the Mid-Atlantic Bight, and occupies this area the year-round (Fig. 22a-b). As with several other odontocetes, the distribution relative to depth, while concentrated along the shelf edge, is broadly defined. Sightings seaward of the 2000 m depth contour occurred in spring, summer, and winter. Sightings on the shelf and shoreward of the 100 m contour occurred in the spring, summer, and fall.

Feeding. There were only two sightings of surface feeding grampus. One was far offshore out of the study area, and the second was over the shelf break near Veatch Canyon (Fig. 22e). These two sightings represent only 0.4% of the total grampus sightings. One was in spring, the other in summer. These two surface feeding sightings were within the general distribution of grampus sightings, most particularly along and seaward of the shelf break offshore waters (Fig.22a).

Grampus feed almost exclusively on squid (Nishiwaki, 1972). They are undoubtedly sub-surface feeders, which accounts for the low numbers of surface feeding sightings. We assume that grampus are, in fact, feeding throughout their general distributional range.

The lone shelf break surface feeding sighting was on the northwestern border of Proposed Lease Area 52. However, there were extremely dense concentrations of grampus sightings in all Lease Areas, particularly 40, 49, and 59 (Fig. 22a). Grampus probably feed in all of the Lease Areas.

Calves and Juveniles. During the three year survey period 58 sightings of grampus calves or juveniles were reported (see figure 22f). The distribution of calves paralleled that of adults with sightings found mostly along the edge of the continental shelf from Cape Hatteras to Cape Cod. Sightings were concentrated east of New Jersey and Delaware. The number of sightings increased from 15 during the spring to a peak of 32 during the summer. Calves were seen 9 times during the fall and only twice during the winter. The pattern of calf distribution did not appear to change over the course of the four seasons.

Calves were found among adult groups ranging in size from 2 to 275 animals. Most groups contained more than 15 animals.

Numerous calf sightings were found within BLM Lease Sale Areas 40, 42, 49, 59, and Proposed Lease Sale Area 52 during all four seasons.

Areas. In the Mid-Atlantic Lease Sale Areas (40, 49, 59), grampus occurs commonly and widespread throughout all four seasons. However, sightings were absent in the northwest portions of 40 and 49 in fall and winter, and were at reduced levels in all three areas in winter. In the North Atlantic, the species is common and widespread in 42 and Proposed 52 in spring and summer, and in Proposed 52 in the fall. No sightings were reported from 42 in fall and winter, or from Proposed 52 in winter.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 16 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 22g. The peak average abundance estimate for grampus in the study area was 11678 (+/- 9041) and occurred during the summer. Correspondingly, the peak average abundance estimate of this species in waters defined as Shelf Edge was 9624 (+/- 8588) during the summer. The maximum point estimate of abundance for this species was 5728 (+/- 14641) in sampling block F during September 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 5094 (+/- 13148) in sampling block F, stratum z, in September 1979.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 278 sightings of this species. The average water temperature for *G. griseus* sightings was 19.5°C, the third warmest for all odontocetes and all small whales. The mode was 23.0, with a range from 4.5 to 27.0°C. Ninety percent of all sightings fell within a relatively wide range of water temperatures (21.3-25.1°C). This corresponds to the wide latitudinal range of *G. griseus* sightings from Cape Hatteras to the Gulf of Maine.

Depth (m). The average depth for *G. griseus* sightings was 1092m. The mode was 183 with a range from 20 to 4938m. Ninety percent of these sightings were made over a relatively wide range of water depths (77 to 2743m). This corresponds well with the concentration of *G. griseus* sightings along the shelf edge.

BEHAVIOR

Associations. Grampus were observed with at least one or more of 9 cetacean species in 7% of the sightings. Seventy-eight percent of these associations, representing at least 6 species, were recorded with other odontocetes (refer to Table 30. Of these, unidentified dolphins, *T.truncatus*, and *Globicephala* spp. (arranged in decreasing order of occurrence) were the most common species present. *B.physalus* was the most frequently observed large whale species, and reported in proximity to *G.griseus* on 5 occasions. Grampus associations typically involved only one additional species, but 2 instances were recorded with as many as 3 additional species present. Of interest is the fact that calves or juveniles were reportedly present in 6.5% of multispecies sightings, while feeding activities were reported in less than 1% of these observations. The significance of this is unknown. In general, though, grampus were only rarely observed in association with another species.

Migration and Movement. The relative abundance data shown in Figure 22d suggest a seasonal expansion and contraction of range and a general influx and egress from the study area. The abundance of grampus in the Mid-Atlantic Bight in winter shows an increase in numbers as well as corresponding northward expansion of range in spring. The general northward shift reaches its maximum in summer, as does the number of individuals (see also Table 16). In fall, both the distributional range and number of individuals remain similar. The winter season experiences a marked contraction in the occupied habitat and an emigration from the study area, to either offshore and/or southern waters.

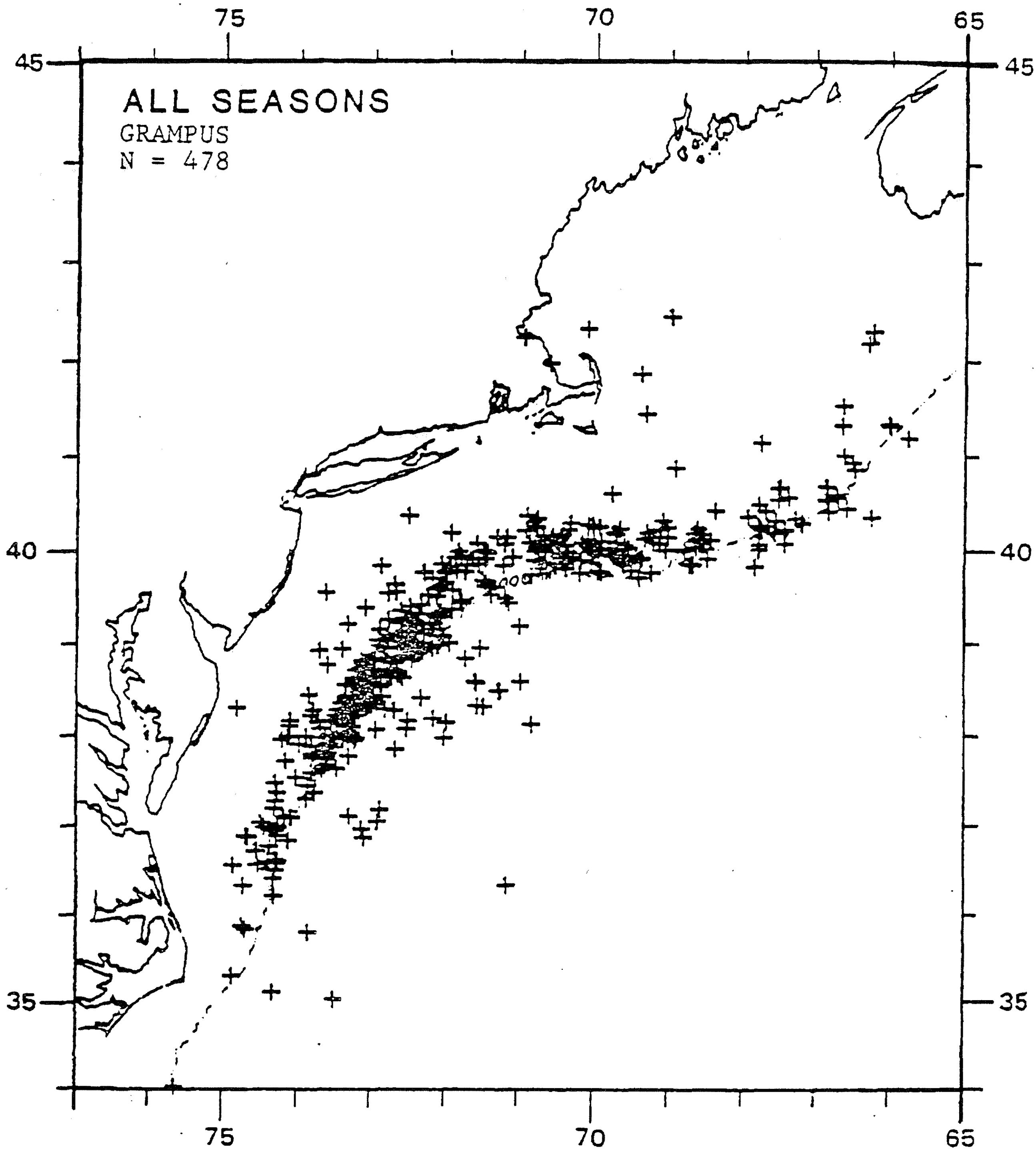

Figure 22a. All sightings of the grampus, *Grampus griseus*, for the 39 month period -- 1 November 1978 through 28 January 1982.

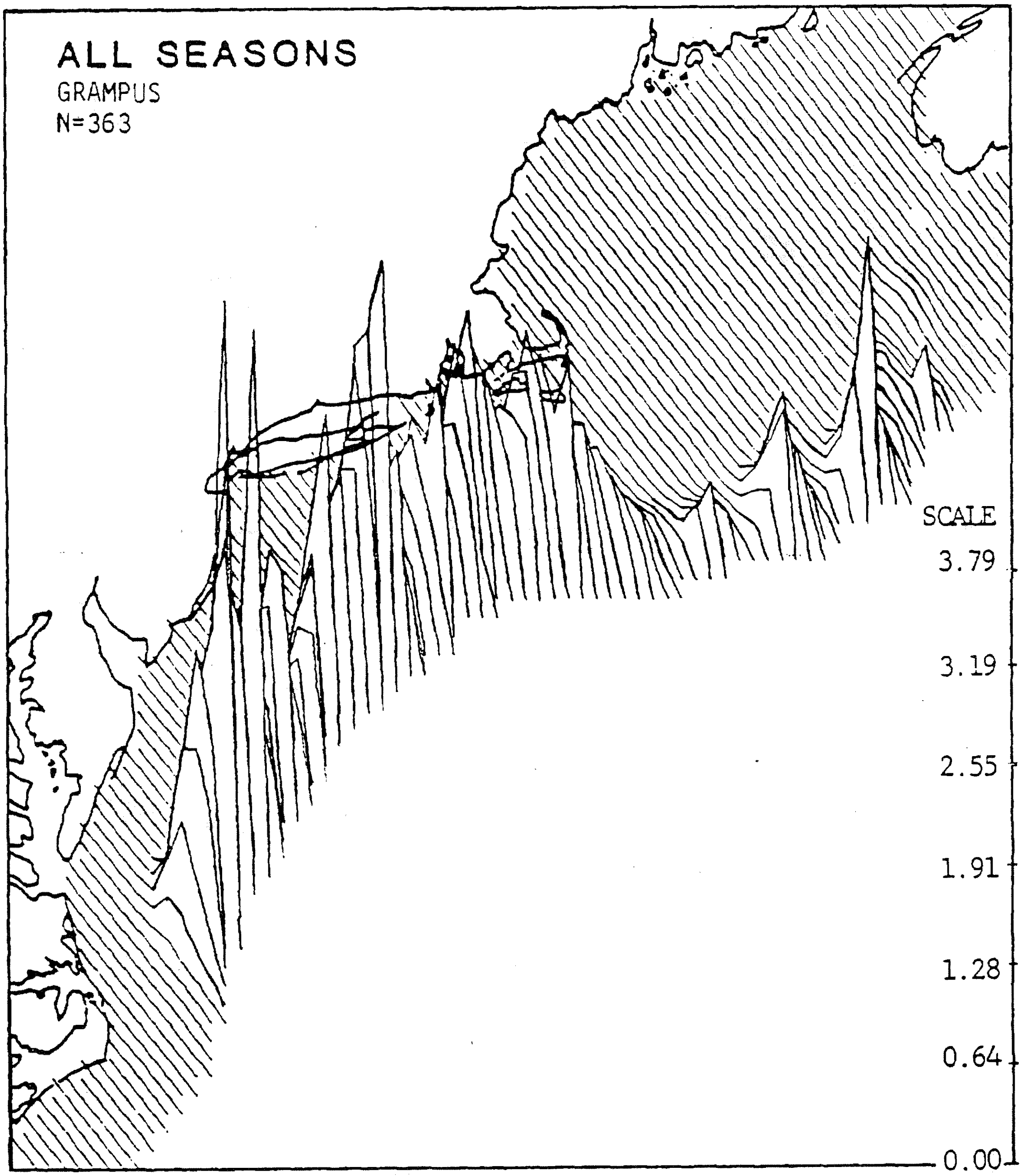

Figure 22b. The relative abundance of G. griseus for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

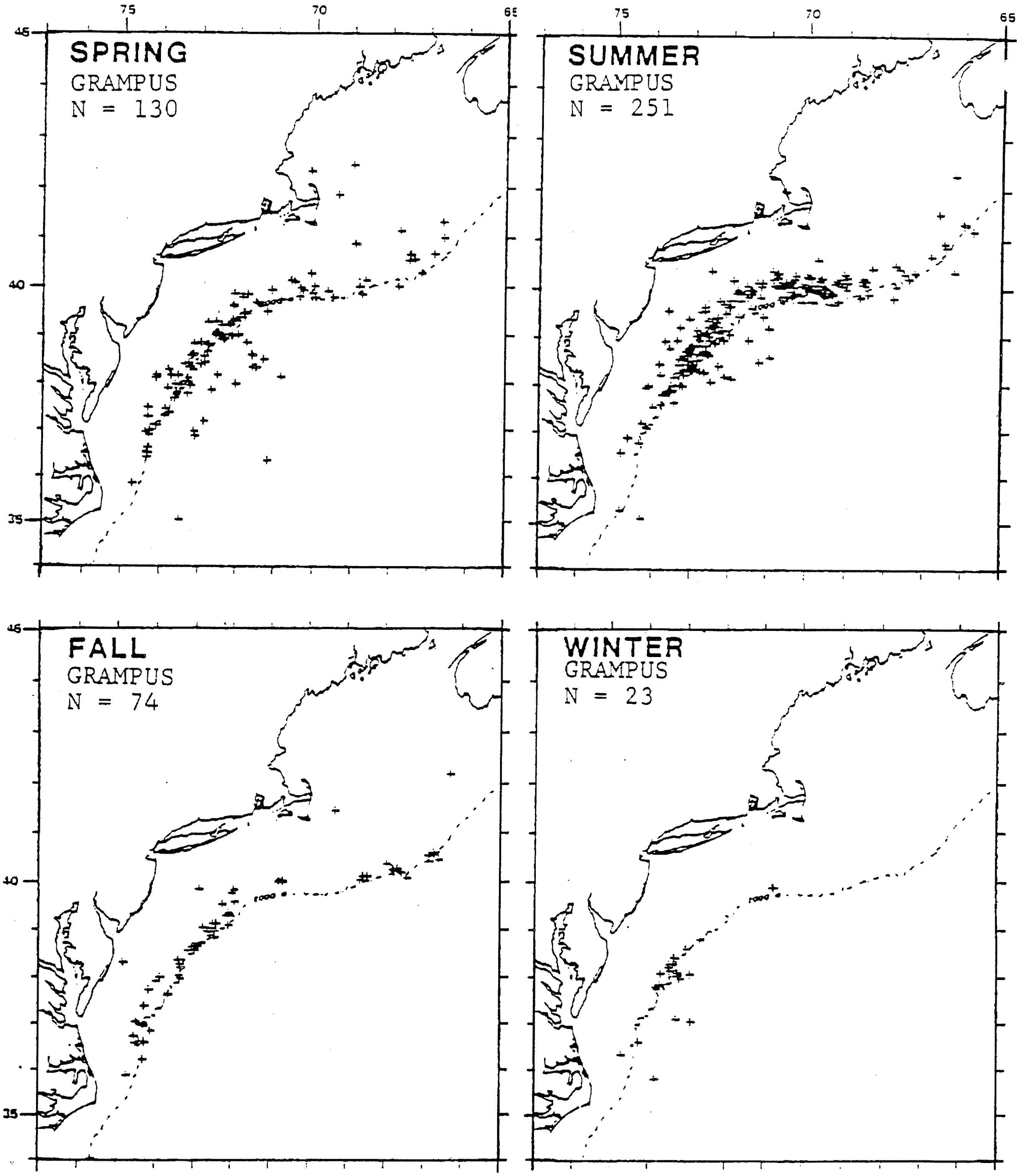

Figure 22c. The sighting distribution of *G. griseus* by season.

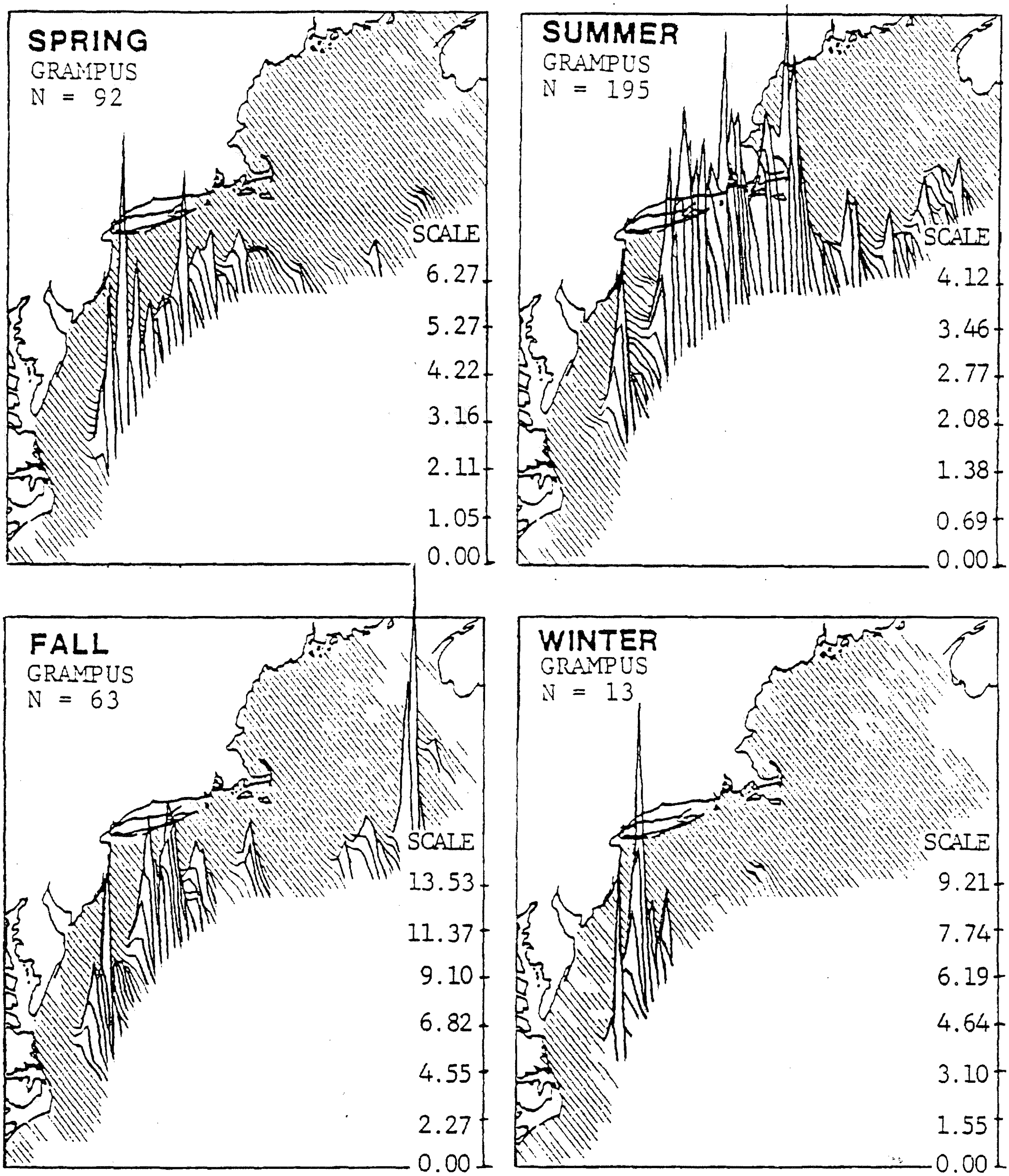

Figure 22d. The relative abundance of G. griseus by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

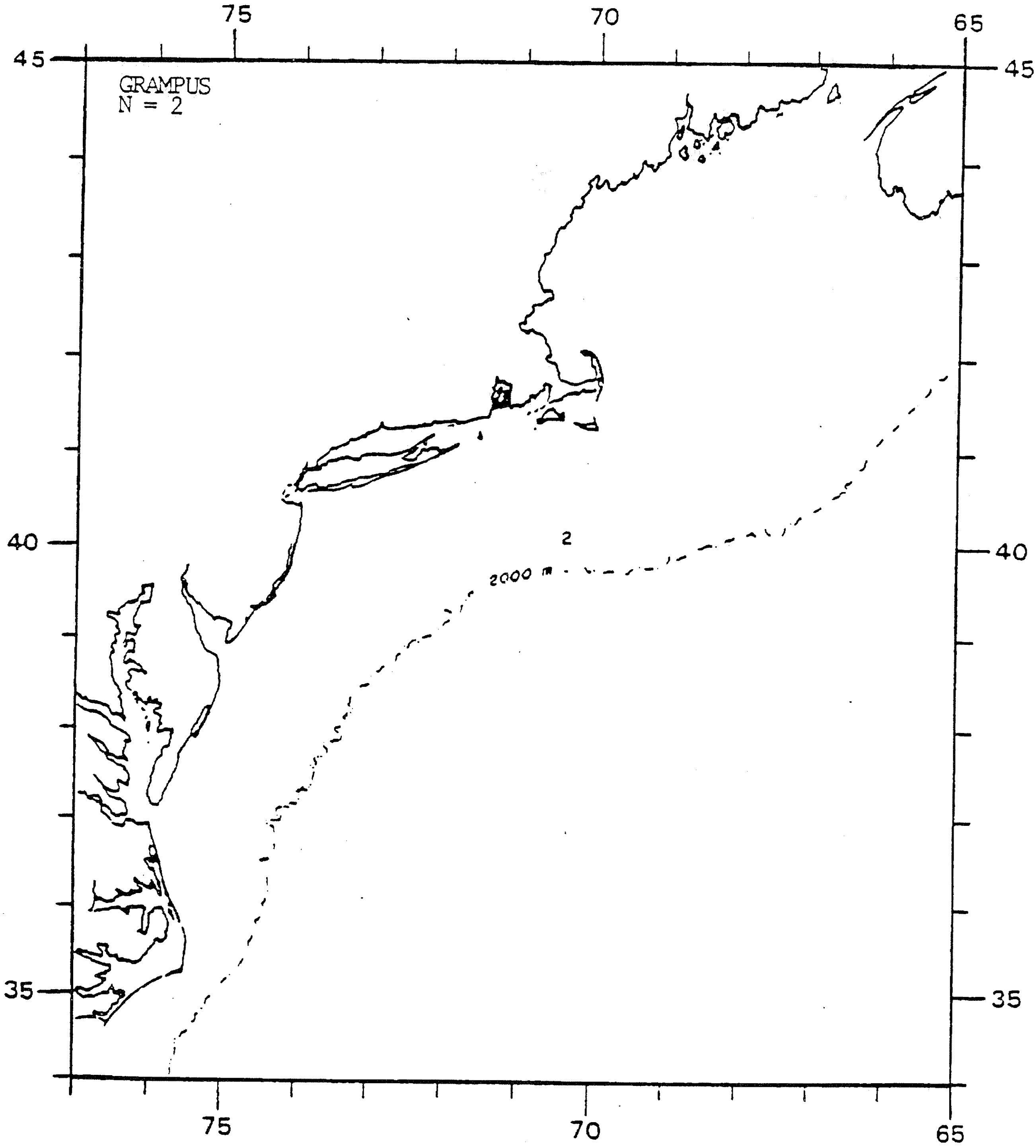

Figure 22e. Locations of sightings of feeding or apparent feeding of G. griseus. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

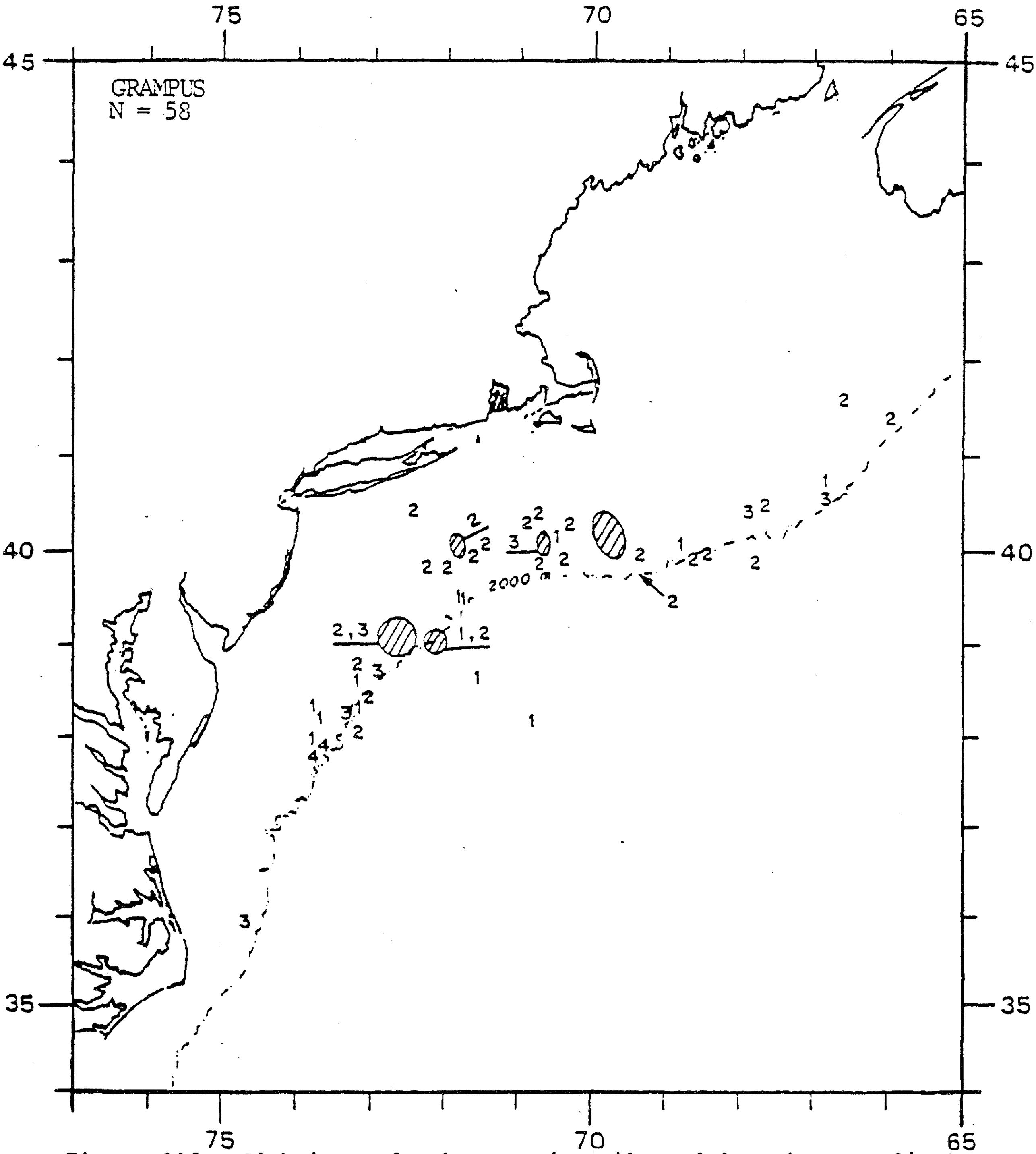

Figure 22f. Sightings of calves or juveniles of G. griseus. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

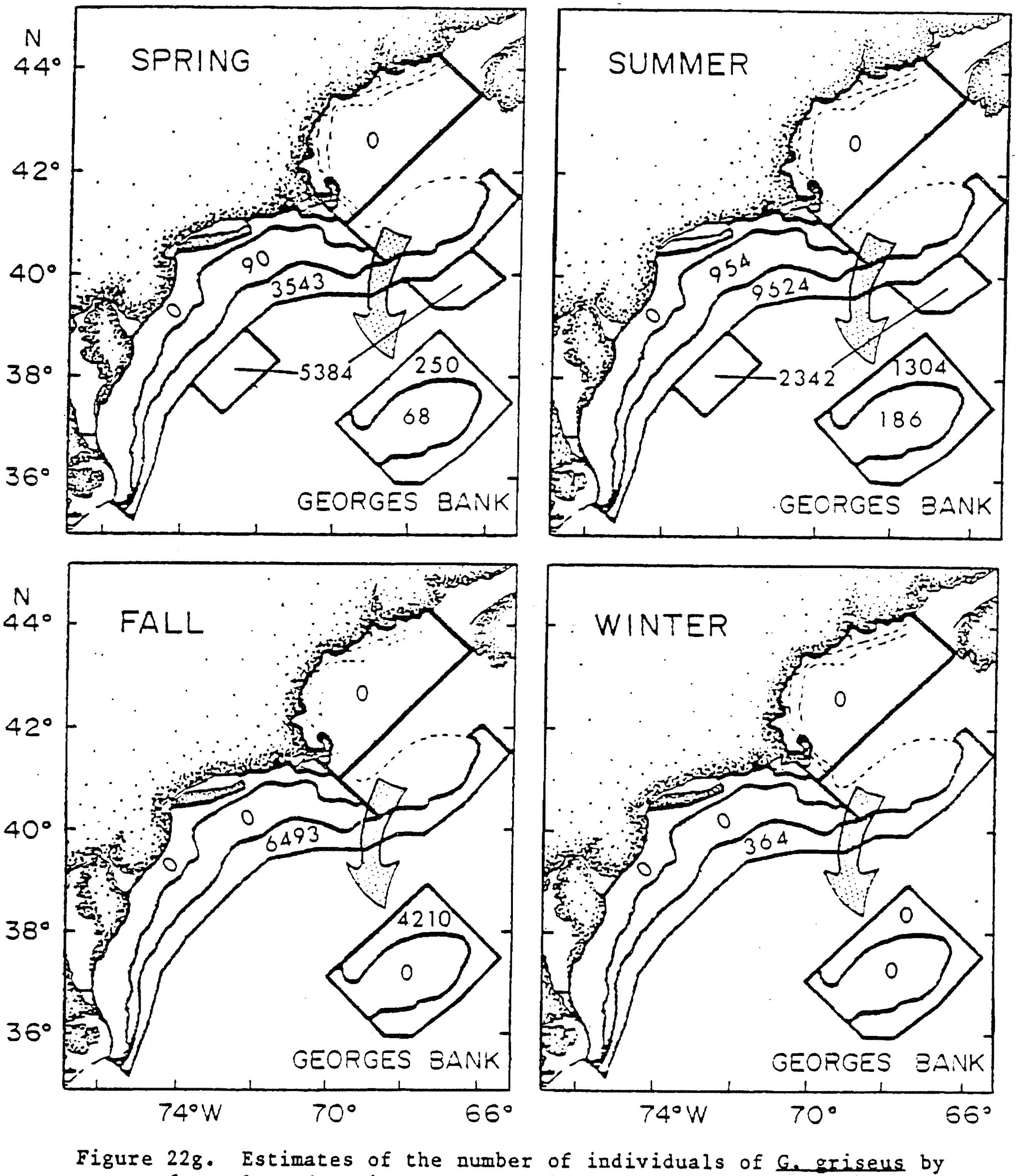

Figure 22g. Estimates of the number of individuals of G. griseus by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 16. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Grampus griseus*.

REGION	SEASON: SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
GEORGES BANK	4.33E-03	1.96E-02	6.50E-02	0.00E+00
	8.71E-04	1.18E-02	6.04E-02	0.00E+00
	299	1353	4488	0
	± 675	± 2847	± 13042	± 0
<50 FATHOMS	2.10E-03	5.75E-03	0.00E+00	0.00E+00
	3.49E-04	9.88E-04	0.00E+00	0.00E+00
	68	186	0	0
	± 310	± 587	± 0	± 0
>50 FATHOMS	6.80E-03	3.56E-02	1.15E-01	0.00E+00
	1.45E-03	2.42E-02	1.07E-01	0.00E+00
	250	1304	4210	0
	± 694	± 3160	± 14874	± 0
LEASE SALE 52	1.60E-02	1.43E-01	8.76E-02	0.00E+00
	3.35E-03	9.88E-02	8.14E-02	0.00E+00
	445	3979	2442	0
	± 830	± 5297	± 8351	± 0
MID-ATLANTIC	2.16E-02	7.00E-02	1.67E-02	4.97E-03
	1.27E-02	4.74E-02	1.42E-02	1.53E-03
	2967	9605	2295	682
	± 3734	± 8123	± 4891	± 1358
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	1.72E-03	1.82E-02	0.00E+00	0.00E+00
	4.45E-04	3.42E-03	0.00E+00	0.00E+00
	90	954	0	0
	± 478	± 1574	± 0	± 0
NEW YORK BIGHT	3.83E-02	8.30E-02	2.20E-02	8.78E-03
	2.57E-02	5.95E-02	2.24E-02	2.28E-03
	2376	5146	1363	545
	± 4103	± 6710	± 4769	± 1428
SHELF EDGE	5.71E-02	1.55E-01	1.05E-01	5.86E-03
	3.26E-02	1.12E-01	9.78E-02	2.18E-03
	3543	9624	6493	364
	± 4350	± 8588	± 11735	± 1254
CONTINENTAL SLOPE	1.74E-01	7.59E-02	.	.
	7.98E-02	1.81E-02	.	.
	5384	2342	.	.
	± 7295	± 37319	± .	± .
STUDY AREA OCS*	3526	11678	5384	762
	± 4082	± 9041	± 8717	± 1516

*Study area OCS does not include the slope water regions.

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Delphinus delphis - Saddleback dolphin

INTRODUCTION

1981 Data. The 1981 data were consistent with the data from CETAP studies in 1979 and 1980. The sections below describe the cumulative results.

Number of Sightings. *D. delphis* was the sixth most commonly sighted small whale in the study area but was the second most abundant species on the basis of total number of individuals. The 453 sightings of 24,708 individuals accounted for 11% of the total small whale sightings, and 10% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average group size was 54.8, the second largest for all odontocetes and all small whales. The mode was 8, with a range from 1 to 2000.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The saddleback dolphin occurs in a broad band along the shelf edge throughout the study area on a year-round basis (Figures 23a-d). The distribution of sightings is notably inshore of most shelf edge odontocetes (centered about the 100 or 200 m depth contour), and may indicate habitat preference or partitioning of the environment. The distribution does extend shoreward, and saddleback dolphins are found over the shelf in all seasons, particularly in the northern portion of the study area. The distribution likewise extends seaward of the 2000 m contour, and at least during the spring, summer, and winter, the species is found out over the slope, rise, and deep ocean basin. The seasonal distribution, as shown by the sighting distribution data (Figure 23c), the relative abundance data (Figures 23d), and population estimates (Table 17), is directly opposite that of other cetaceans, in that the lowest levels are in summer and higher levels are in winter. During spring, the species is rather evenly spread throughout the study area. However, in the fall the area of common occurrence has shifted northward and is over the shelf north of Block Canyon and over southern Georges Bank.

Feeding. Sightings of surface feeding saddleback dolphins were spread over the Great South Channel, edges of Georges Bank, and along the shelf break in the southern regions of the study area (Fig. 23e). These sightings represented some 2.4% of the total sightings. The feeding sightings were scattered throughout the year.

Saddleback dolphins feed on pelagic fish (Tomilin, 1957), and squid (Sergeant, 1958). Although often characterized as a pelagic dolphin saddleback dolphins do frequent shallower waters, e.g., on Georges Bank (Fig. 23a). They are undoubtedly primarily sub-surface feeders, and the small percentage of surface feeding observations is not an accurate indication of their total feeding range. It is reasonable to assume that the saddleback dolphins must be sub-surface feeding throughout the regions in which general sightings were made.

Despite the paucity of feeding observations on saddleback dolphins, nearly 40% of the surface feeding observations were made in Lease Areas 40, 49, 59, 42 and Proposed Area 52. In addition, there were significant numbers of general sightings throughout all of the Lease

Areas. Therefore, it is probable that the Lease Areas are regions of significant saddleback dolphin feeding activity both at the surface and below.

Calves and Juveniles. During the three year survey period 60 sightings of calves or juveniles were reported (Figure 23f). Calves were distributed in much the same way as adults, along the edge of the continental shelf from Virginia to Cape Cod. The location of calf sightings was similar for all seasons although relatively few calves (5 sightings) were seen during summer months.

No information is available about the calving behavior of northwest Atlantic saddleback dolphins. In the Black Sea, calves are born most frequently during the summer, and in the North Pacific during the spring and fall (Katona et al., 1978). The reason for the scarcity of calf sightings during summer is unknown.

Calves were found among adult groups ranging in size from 3 to 600 individuals. Most calves were found in groups larger than 20 animals. A few calves were found within Lease Sale Areas 40, 42, 49, and 59 during the spring, fall and winter, and within Proposed Lease Sale Area 52 during the spring and winter.

Areas. *D. delphis* is common and widespread in all of the Mid-Atlantic Lease Sale Areas (40, 49, 59), except for the extreme northwestern portion of 40 and 49 in spring, summer, and winter. In fall, only a single sighting was reported from within the boundaries of these areas. In the North Atlantic, the species is widespread and common in Lease Sale 42 in fall and winter, and occurs there infrequently in spring and summer. The species is widespread and common in Proposed Lease Sale 52 in spring, fall, and winter, and occurs there infrequently in summer.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 17 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 23g. The peak average abundance estimate for saddleback dolphins in the study area was 31124 (+/- 36151) and occurred in the winter. The maximum point abundance estimate for this species was 34285 (+/- 71487) in sampling block E, stratum y, during January 1981. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. The high degree of variation in these estimates is primarily attributable to the variation in pod sizes. Nishiwaki (1972) estimated the North Atlantic stock(s) of this species to be in excess of 30,000 individuals.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 207 sightings of this species. The average water temperature for D. *delphis* sightings was 13.7°C, the third coolest for odontocetes and also small whales. The mode was 9.0 with a range from 1.0 to 24.0°C. Ninety percent of all sightings fell within a relatively wide range of water temperatures (7.0-22.4°C).

Depth (m). The average depth for D. delphis sightings was 844m. The mode was 91 with a range from 26 to 5121.

BEHAVIOR

Associations. Multispecies aggregations were reported for 7% of all sightings of saddleback dolphins. Unidentified dolphins, B. physalus, Globicephala spp., and S. coeruleoalba (13 occasions, and 5, 5, and 5 occasions respectively) were the most frequent species observed with D. delphis. Less frequent associations include at least 4 species of large or small whales as noted in Table 30. In general, CETAP data indicate that saddleback dolphins only infrequently or rarely associate with other species.

Migration and Movement. As the distribution data suggest, the migration into and out of the study area appears to be out of phase by about six months with the migrations of other cetaceans. There appears to be an emigration from the study area in late spring, and a subsequent return migration in early fall. It is not clear at present what other areas may be involved in this migration.

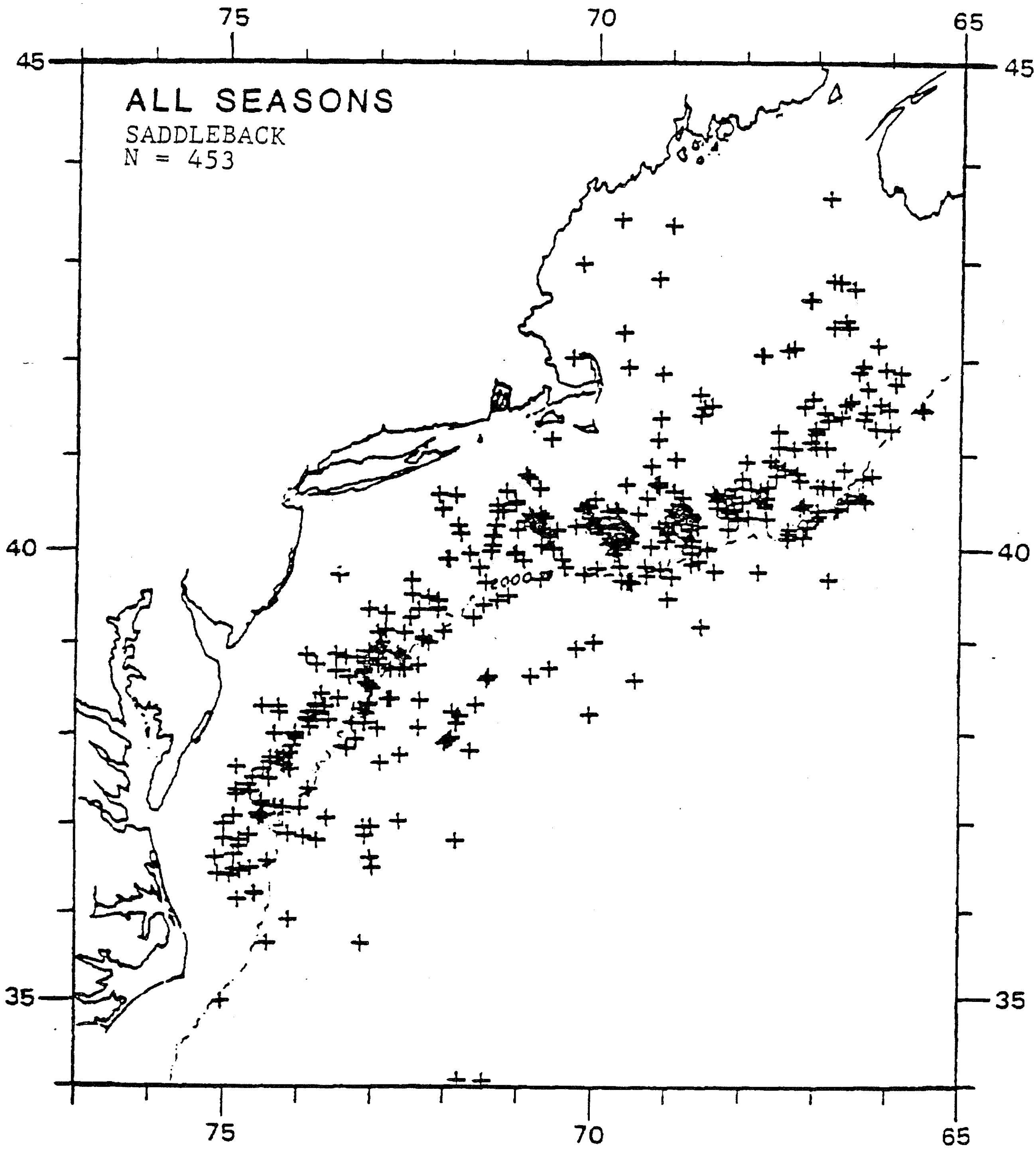

Figure 23a. All sightings of the saddleback dolphin, *Delphinus delphis*, for the 39 month period -- 1 November 1978 through 28 January 1982.

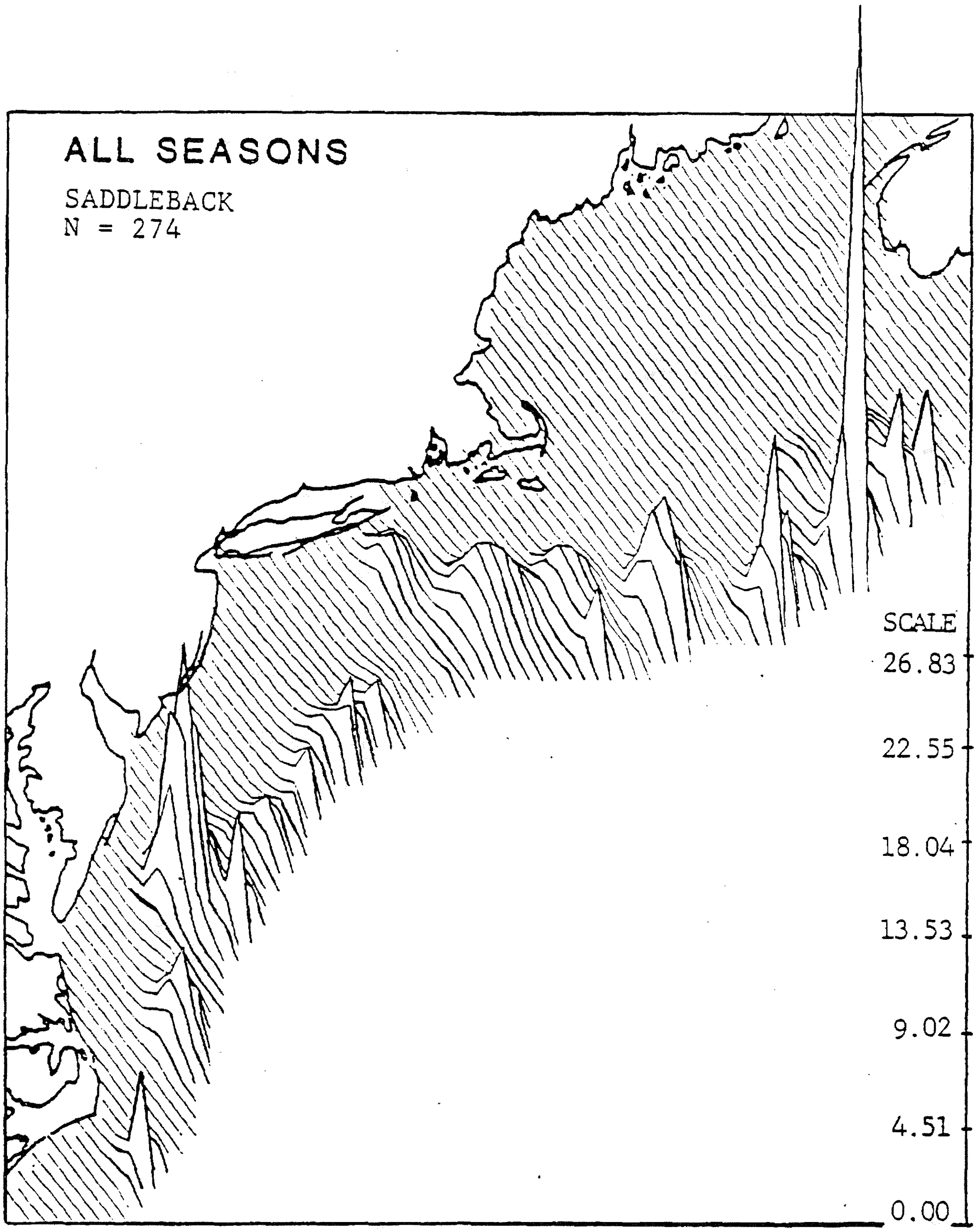

Figure 23b. . The relative abundance of D. delphis for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

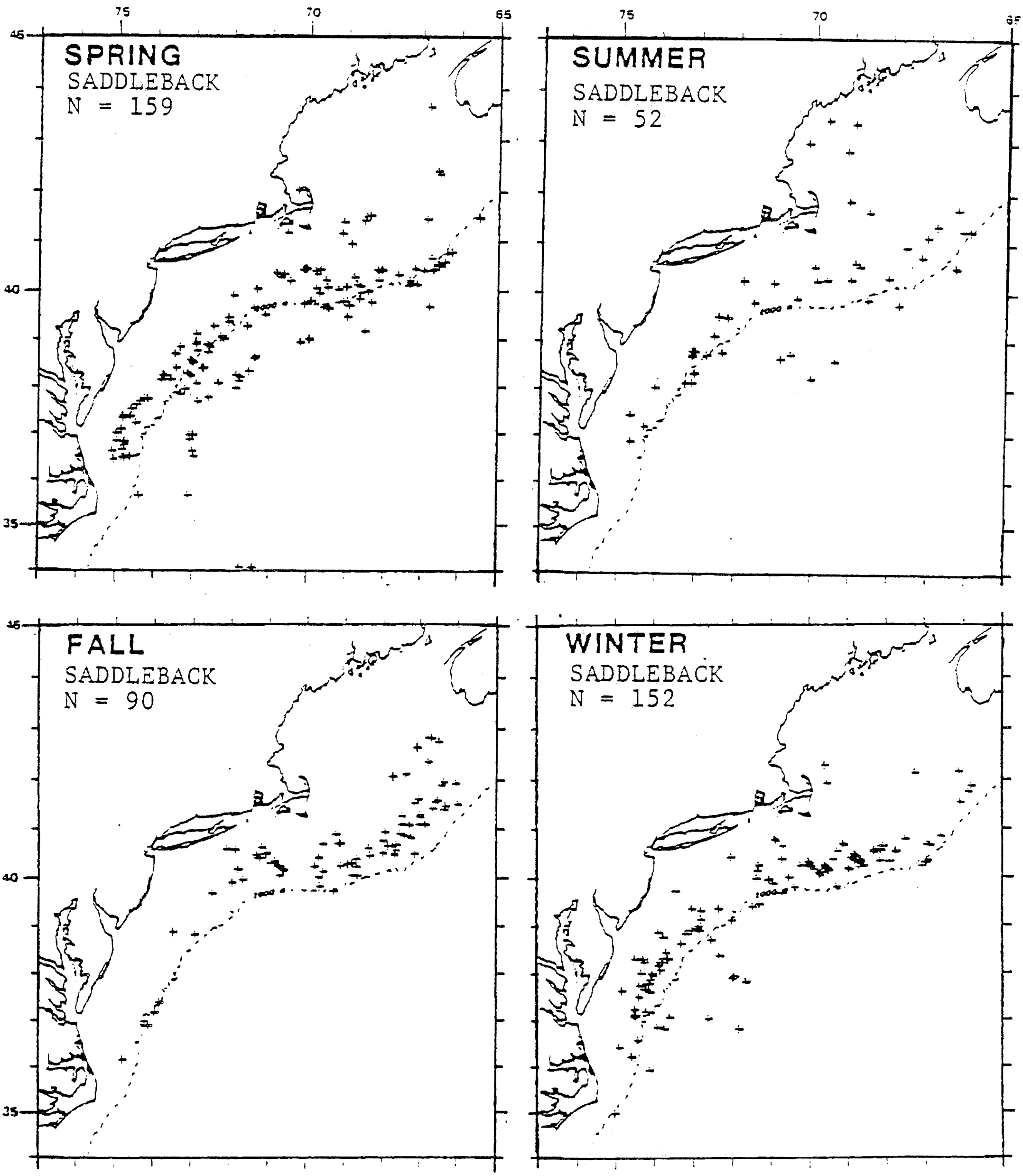

Figure 23c. The sighting distribution of D. delphis by season.

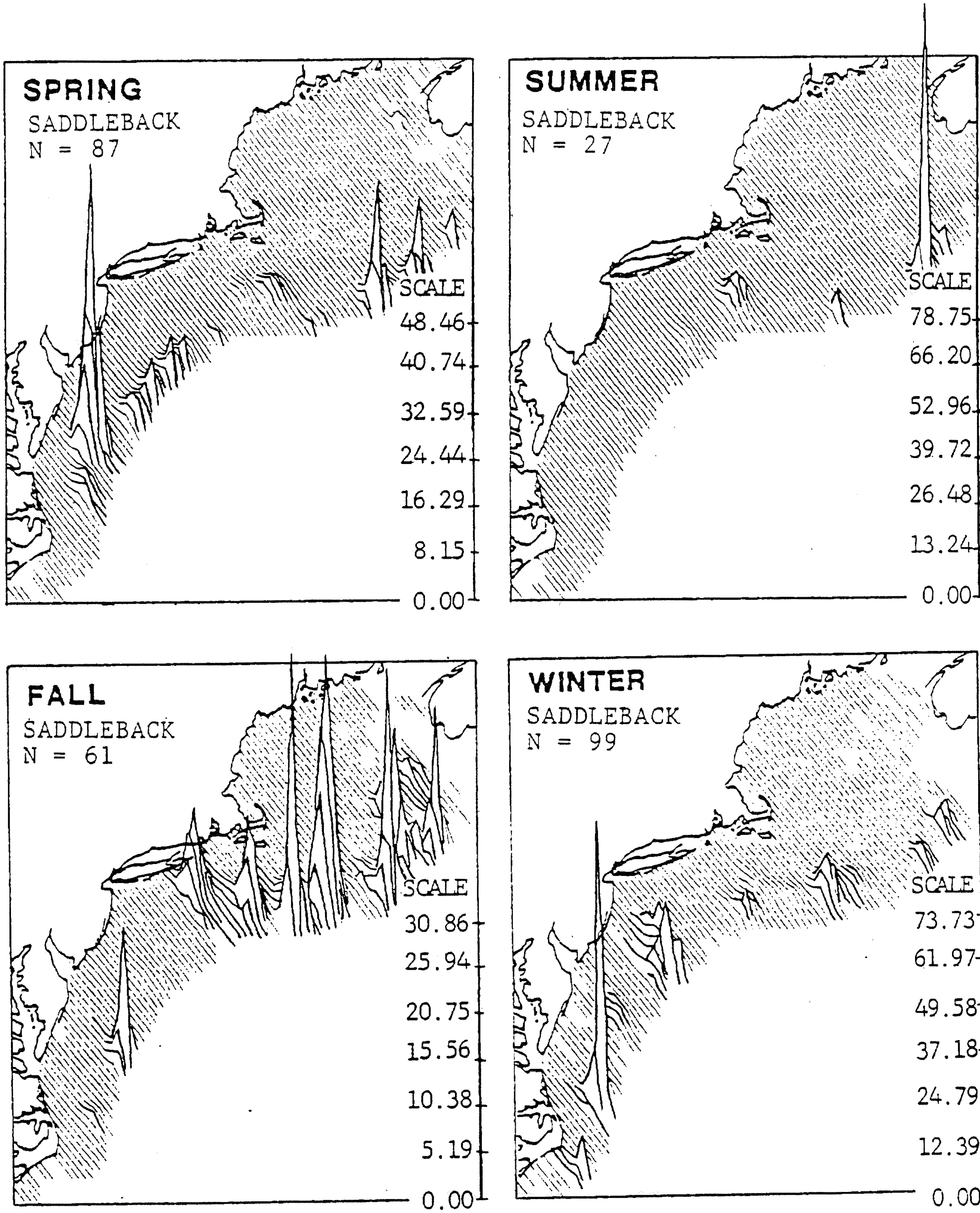

Figure 23d. The relative abundance of D. delphis by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

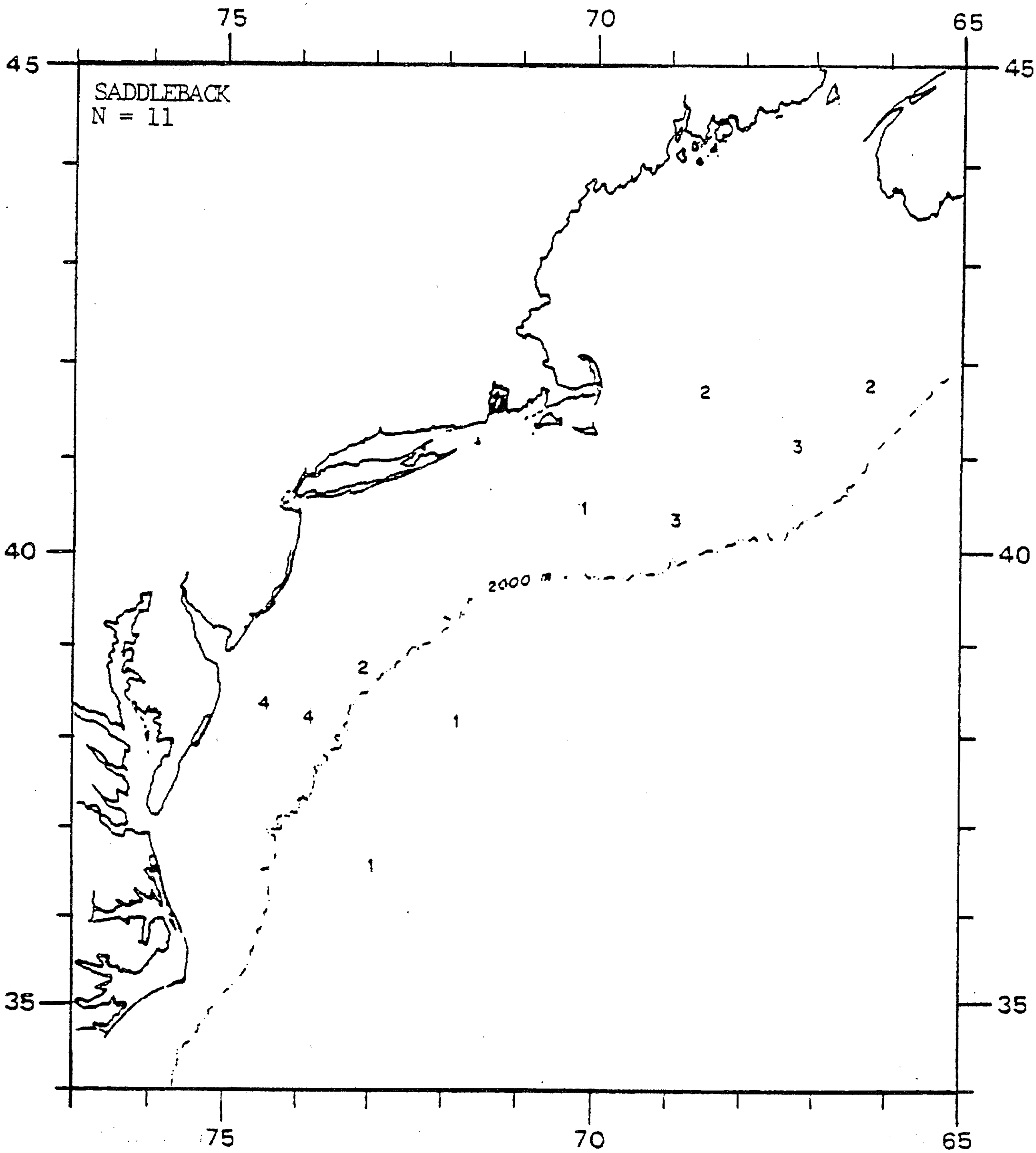

Figure 23e. Locations of sightings of feeding or apparent feeding of D. delphis. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

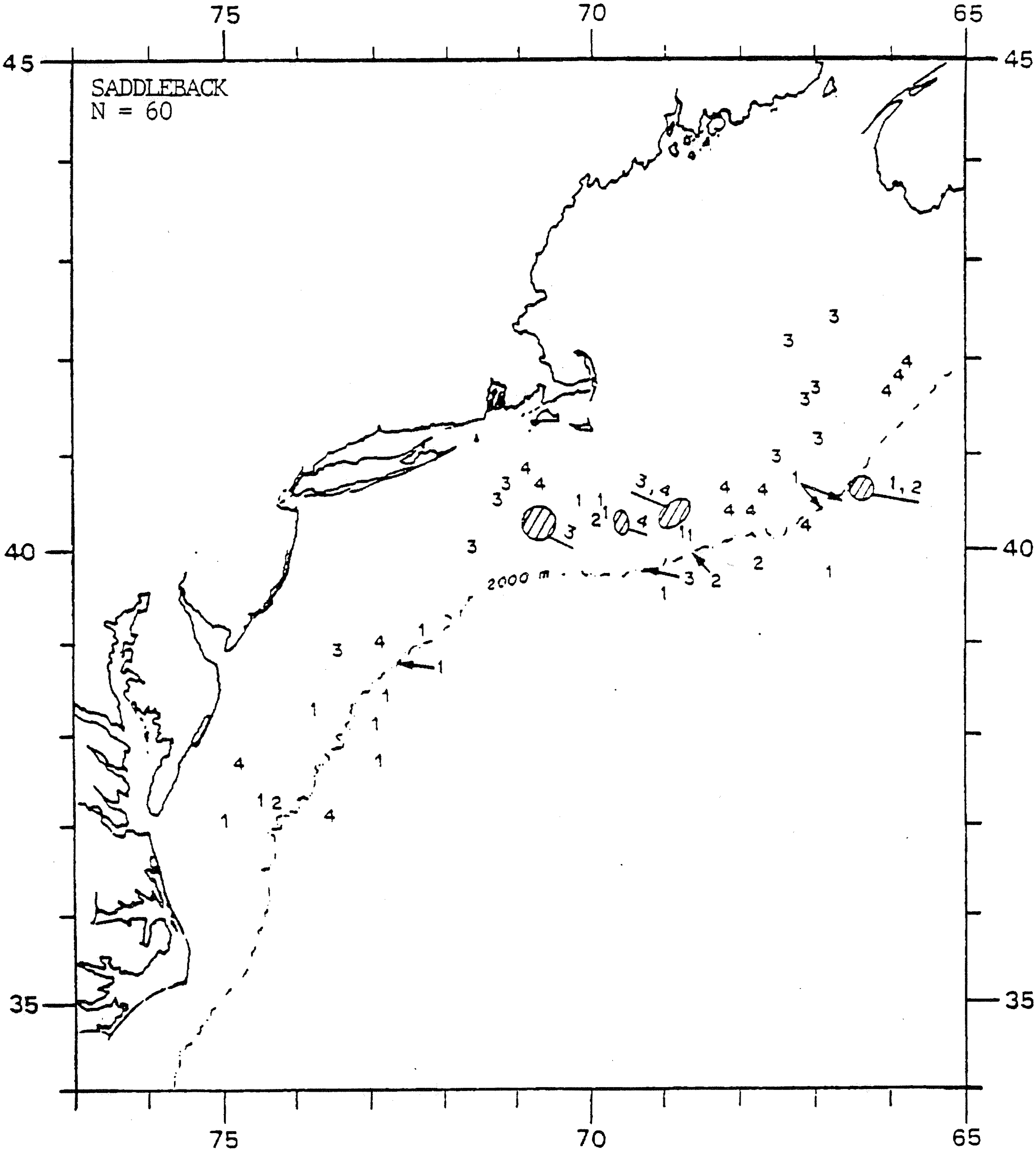

Figure 23f. Sightings of calves or juveniles of D. delphis. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

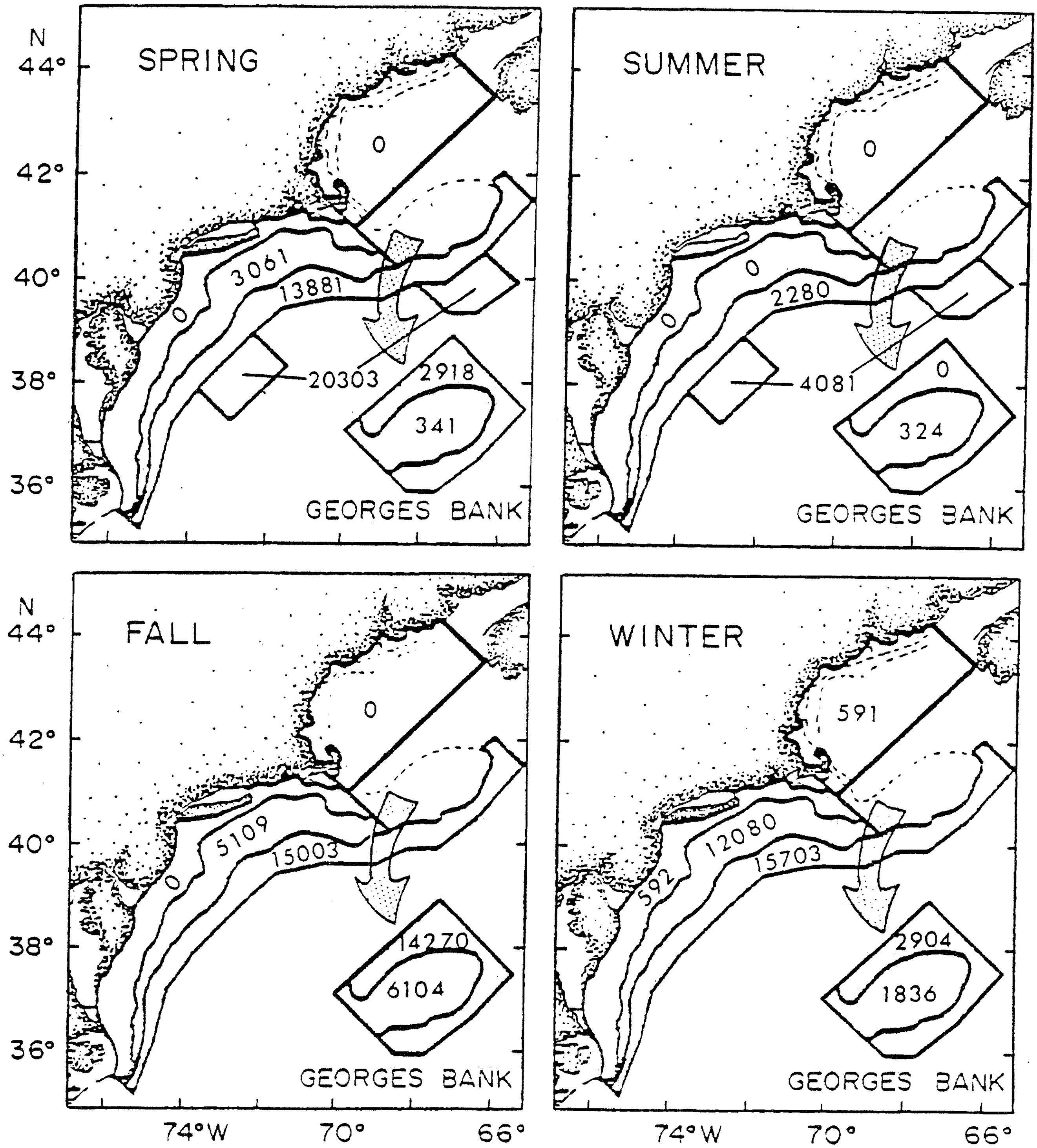

Figure 23g. Estimates of the number of individuals of D. delphis by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 17. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Delphinus delphis*.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	8.20E-03
	0.00E+00	0.00E+00	0.00E+00	6.80E-03
	0	0	0	591
	± 0	± 0	± 0	± 2453
GEORGES BANK	4.33E-02	5.37E-03	3.02E-01	5.09E-02
	1.02E-01	4.68E-03	8.12E-01	1.20E-01
	2988	371	20858	3515
	± 7290	± 1796	± 47793	± 10117
<50 FATHOMS	1.06E-02	1.00E-02	1.89E-01	5.68E-02
	1.17E-02	8.75E-03	3.67E-01	1.77E-01
	341	324	6104	1836
	± 1800	± 1745	± 31144	± 9719
>50 FATHOMS	7.95E-02	0.00E+00	3.89E-01	7.92E-02
	2.01E-01	0.00E+00	1.15E+00	1.48E-01
	2918	0	14270	2904
	± 8184	± 0	± 48883	± 9467
LEASE SALE 52	1.96E-01	2.15E-02	5.00E-01	2.91E-01
	5.42E-01	1.54E-02	1.46E+00	9.36E-01
	5468	599	13938	8120
	± 10554	± 2088	± 35378	± 14944
MID-ATLANTIC	9.46E-02	1.70E-02	7.67E-02	1.78E-01
	2.60E-01	1.79E-02	1.76E-01	8.22E-01
	12990	2334	10523	24471
	± 16899	± 4989	± 17200	± 31484
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	1.45E-02
	0.00E+00	0.00E+00	0.00E+00	1.71E-02
	0	0	0	592
	± 0	± 0	± 0	± 2429
MID-SHELF	5.85E-02	0.00E+00	9.76E-02	2.31E-01
	1.00E-01	0.00E+00	1.65E-01	1.32E+00
	3061	0	5109	12080
	± 7171	± 0	± 11780	± 27433
NEW YORK BIGHT	8.41E-02	2.38E-02	2.82E-02	1.13E-01
	2.81E-01	2.91E-02	2.43E-02	2.94E-01
	5217	1478	1749	7036
	± 13571	± 4690	± 4967	± 16198
SHELF EDGE	2.24E-01	3.67E-02	2.42E-01	2.53E-01
	6.72E-01	3.86E-02	7.44E-01	8.04E-01
	13881	2280	15003	15703
	± 19734	± 5037	± 32360	± 24071
CONTINENTAL SLOPE	6.58E-01	1.32E-01	.	.
	1.62E+00	1.50E-01	.	.
	20303	4081	.	.
	± 32812	± 107497	± .	± .
STUDY AREA OCS*	17259	2884	24828	31124
	± 19877	± 5570	± 31250	± 36151

*Study area OCS does not include the slope water regions.

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Stenella spp. - Spotted dolphins

INTRODUCTION

Taxonomy and Identification. The identification and taxonomy for the two species of spotted dolphins found in the western North Atlantic (*Stenella plagiodon* and *Stenella attenuata/frontalis*) remains unresolved at present. Therefore, CETAP continues with the practice of grouping all sightings of spotted dolphins into the category of *Stenella* spp. (spotted).

1981 Data. The 1981 data were consistent in all respects with those reported in the 1979 and 1980 CETAP Annual Reports. The sighting of 40 individuals (I.D. reliability = "sure") on 22 August 1981 south of Block Island extends northward by about 50 miles the sightings of this species group, and is unique in that it is the only on-shelf sighting north of the Delmarva Peninsula. The overall small number of sightings of spotted dolphins in 1981 is due largely to the discontinuation of the shipboard platforms-of-opportunity program at the end of 1980. These points are included in the discussion of the cumulative results below.

Number of Sightings. Spotted dolphins were the seventh most commonly sighted small whales in the study area. The 126 sightings of 6044 individuals accounted for 3% of the small whale sightings and 3% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average group size was 48.0, the fourth largest for odontocetes, and also small whale species. The mode was 10 with a range from 1 to 1000.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. Spotted dolphins are broadly distributed on the shelf, along the shelf edge, and offshore over the deep ocean south of 40°N (Figures 24a-d). The majority of the sightings were in the southernmost section of the study area, off the Delmarva Peninsula and southward. There is evidence of a seasonal shift in the general distribution pattern, particularly in winter, when no spotted dolphins were sighted in the study area. The on-shelf occurrence regularly extends northward as far as Cape Charles, VA, and on a more occasional basis to Cape Henlopen, DE. The single sighting south of Block Island, RI, suggests that during the peak northward expansion in summer, spotted dolphins may occasionally occur on the shelf north of NJ, beyond what appears to be their normal range. The deep-ocean sightings indicate that spotted dolphins, as do a number of other odontocetes, regularly inhabit the waters of the deep-ocean.

In general, the two species of spotted dolphins are inhabitants of tropical, subtropical, and warm temperate waters (Katona et al., 1978; Leatherwood et al., 1976; Schmidly, 1981). *Stenella plagiodon* is believed to be the more northerly of the two species. It is replaced after an area of overlap by *Stenella attenuata/frontalis* in the Caribbean. Spotted dolphins, reported as *S. plagiodon*, are frequently sighted around Florida and in the Gulf of Mexico (Katona et al., 1978; Schmidly, 1981). Worthy of note in the discussion of sightings and distribution is that 118 of the 126 total sightings of spotted dolphins were made from shipboard platforms. As with other species within this genus, reliable identifications are often difficult from aerial survey platforms and as a result sightings are often identified to the generic level only. These observations indicate that the sampling platform as well as sighting effort plays a role in describing the distribution of certain species.

Feeding. Spotted dolphins were observed feeding at the surface only twice, both times over the shelf break just off the barrier islands of the Cape Hatteras region (Fig. 24e). These two sightings, one in summer and one in fall, accounted for 1.6% of the total sightings of spotted dolphins. They coincided with a major distributional region of spotted dolphins, i.e., the shelf break area from Cape Hatteras to 39'N.

In the Pacific, spotted dolphins feed on both epipelagic and mesopelagic fish and squid (Fitch and Brownell, 1968; Perrin et al., 1973). Caldwell and Caldwell (1966) reported that Atlantic spotted dolphins feed on epipelagic fish and unknown squid. These reports indicate that surface feeding is common in spotted dolphins, and one might have expected to see more feeding activity in the current study. However, we do not know the relative proportions of epipelagic diet items for spotted dolphins in the study area. Furthermore, epipelagic fish may still be captured below the surface, and such feeding would not necessarily be visible to observers. Hence, it is likely that spotted dolphins are feeding sub-surface throughout the regions in which general sightings were made.

There were no surface feeding sightings in any lease areas. However, general sightings of spotted dolphins were made in Areas 40, 49, 59, and Proposed Area 52. It is likely that spotted dolphin feeding occurs in all of these lease areas.

Calves and Juveniles. During the three year survey period, 24 sightings of calves or juveniles were reported (Figure 24f). The distribution of calves was similar to that of adults, with sightings concentrated close to the shelf edge in the Cape Hatteras area, and more diffusely scattered in both shallow and deep water from Virginia to New Jersey.

The distribution and frequency of sightings were similar for the spring, summer and fall seasons; no calves were seen during the winter.

No information is available about calving behavior among spotted dolphins.

Calves were found among adult groups ranging in size from 2 to 300 animals. Most groups contained more than 20 animals.

One calf sighting was made within Lease Sale Areas 40, 49, and 59. None were reported from Lease Sale 42 or Proposed Lease Sale 52.

Areas. Spotted dolphins were sighted on an infrequent and scattered basis in the Mid-Atlantic Lease Sale Areas (40, 49, 59). Four sightings were in spring, with one apiece in summer and fall. In the North Atlantic, spotted dolphins are infrequent and widely scattered inhabitants of Proposed Lease Sale 52. Three sightings were in summer, and one sighting was in the fall. There were no sightings of spotted dolphins reported in Lease Sale 42.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 18 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 24g. The peak average abundance of spotted dolphins in the study area was 190 (+/- 291) and occurred during the spring. Correspondingly, the peak average abundance for these species in the region defined as Shelf Edge (202 +/- 313) also occurred during the spring. The maximum point abundance estimate was 534 (+/- 1125) in sampling block G in April 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 423(+/- 662) in sampling block F, stratum z, in May 1979.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 6 sightings of this species. The average water temperature for *Stenella* spp. sightings was 20.4°C, the warmest for odontocetes, and also for all small whale species. This would be expected since most spotted dolphin sightings were found south of New Jersey. The range of temperature was from 10.3 to 28.0°C.

Depth (m). The average depth for *Stenella* spp. sightings was 1250m, the sixth deepest for odontocetes, and fourth deepest for small whales. The mode was 15, with a range from 15 to 4209m. Ninety percent of these sightings were made over a wide range of water depths

(19 to 3963m). This is not surprising since spotted dolphins were found in equal concentrations along the continental shelf, along the shelf edge, and seaward of the shelf edge.

BEHAVIOR

Associations. *Stenella* spp. (spotted) were observed with another cetacean species in 6% of the sightings of spotted dolphins. Four occurrences with Globicephala spp., two occurrences with unidentified whales; and single occurrences with *P. catodon* and *S. coeruleoalba* account for all the multispecies aggregations involving spotted dolphins. It should be noted that, in 15% of these sightings, the presence of young spotted dolphins (calves or juveniles) were recorded.

Migration and Movement. Based on the seasonal nature of the distribution, a southward or offshore migration preceding the winter season is suggested.

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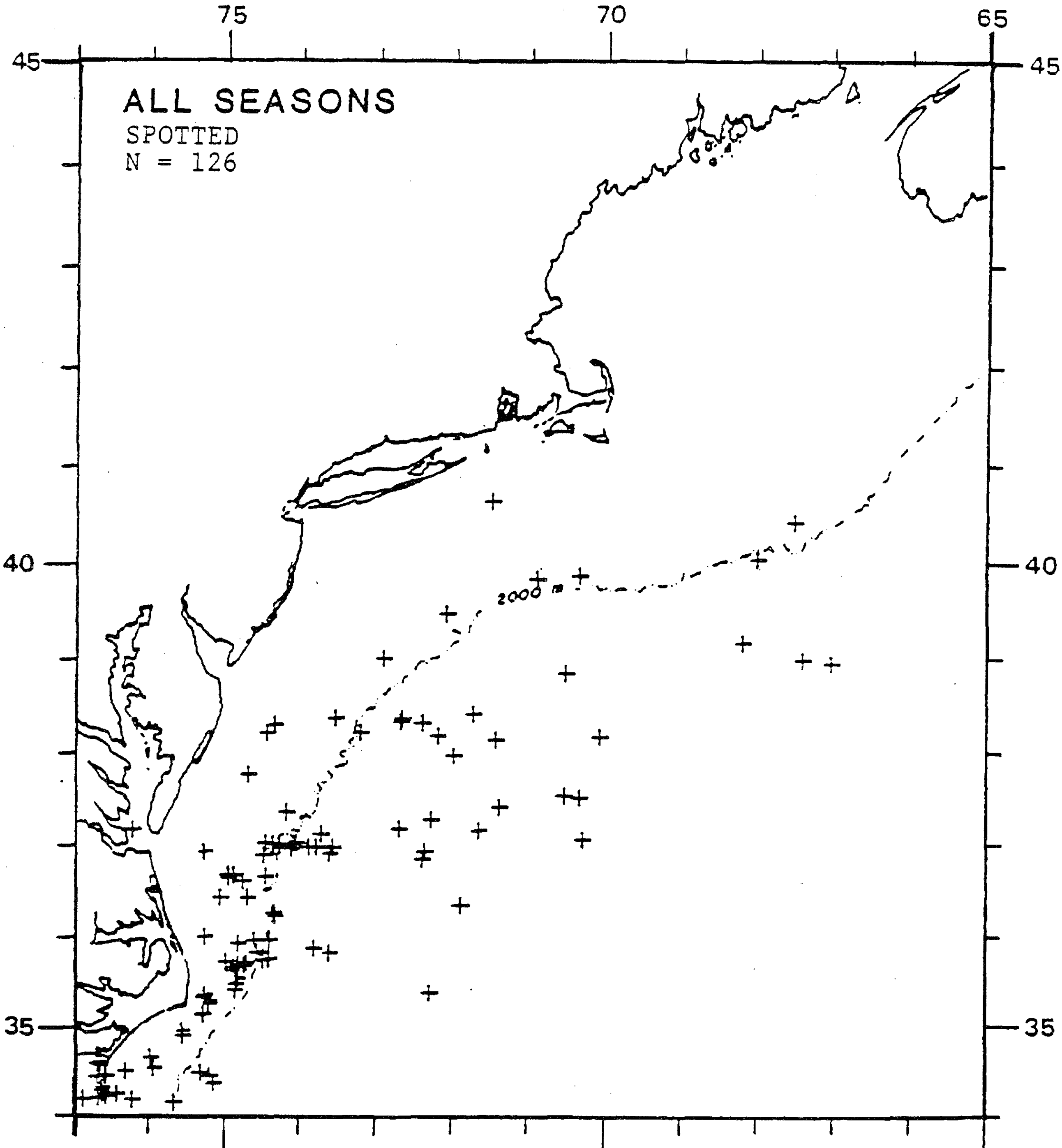

Figure 24a. All sightings of the spotted dolphin, Stenella spp. for the 39 month period -- 1 November 1978 through 28 January 1982.

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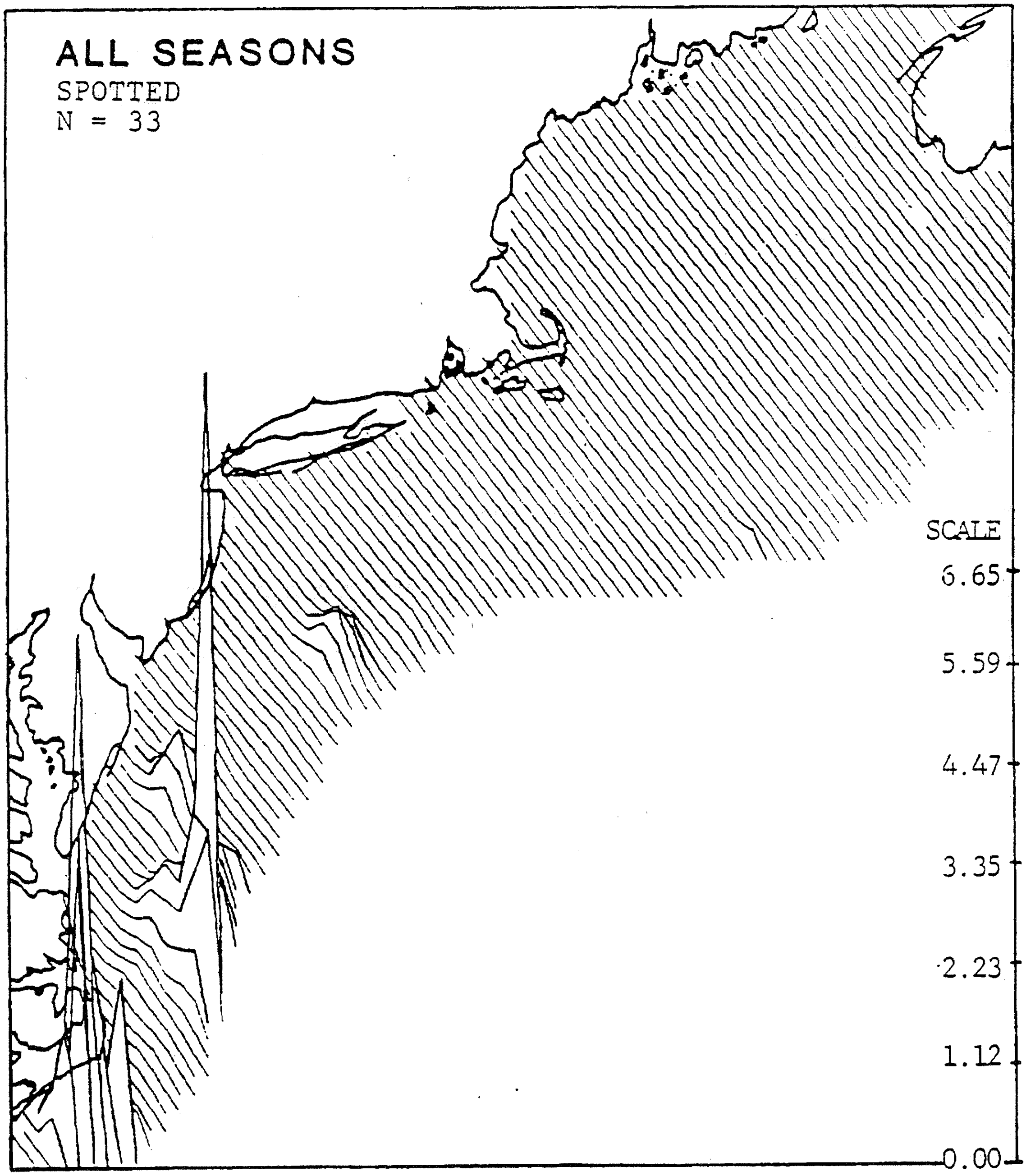

Figure 24b. The relative abundance of Stenella spp. for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

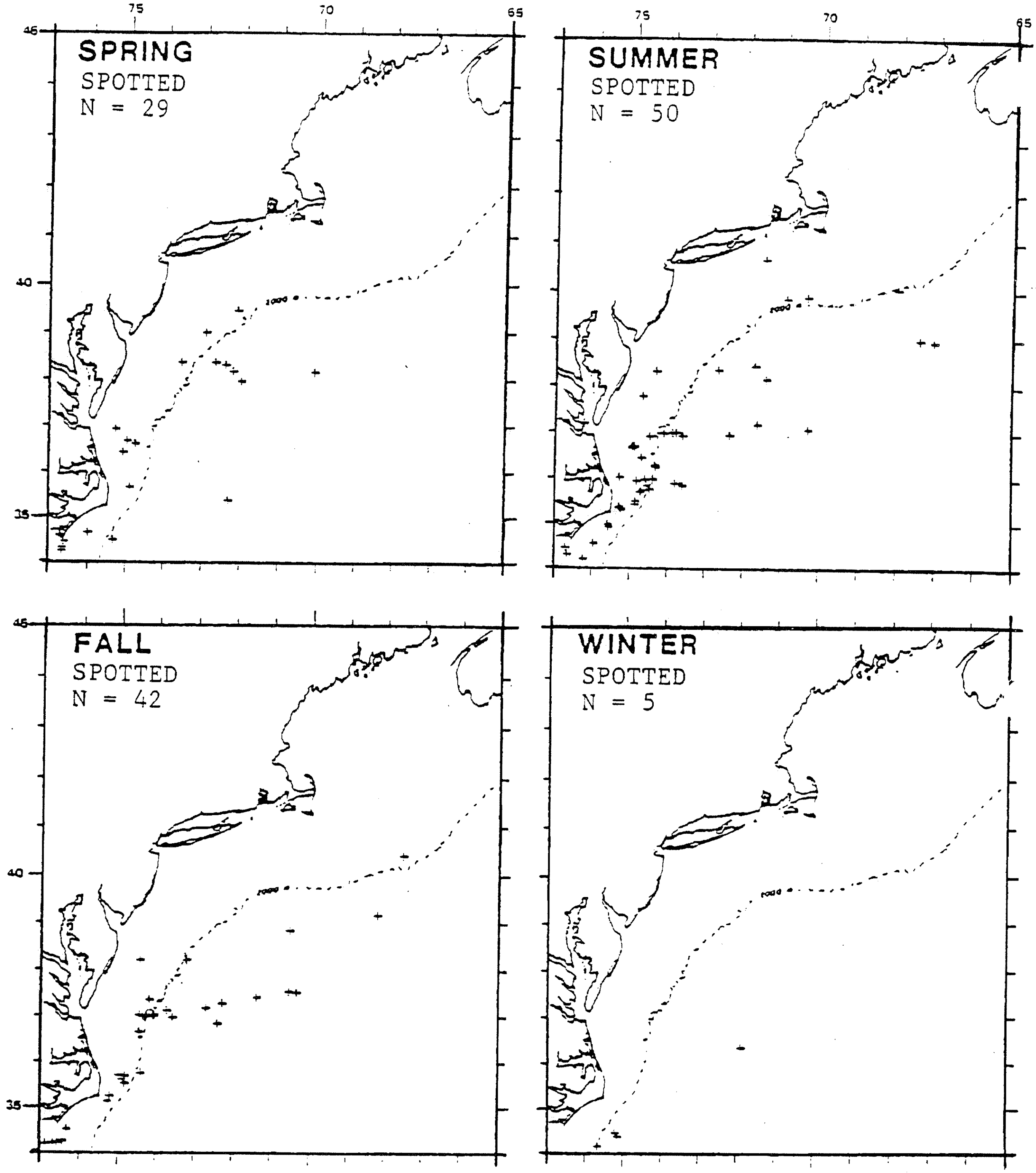

Figure 24c. The sighting distribution of _Stenella_ spp. by season.

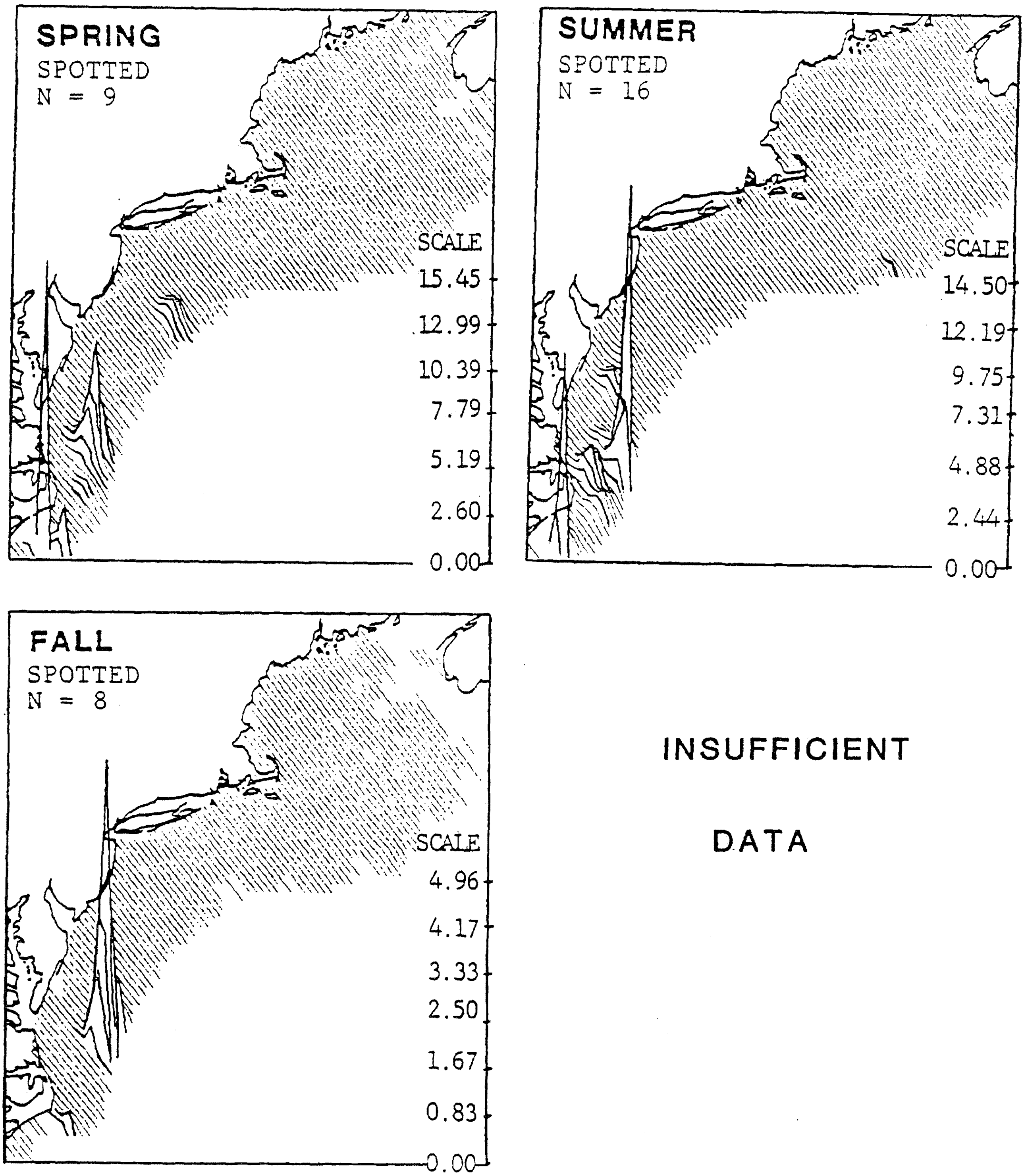

Figure 24d. The relative abundance of *Stenella* spp. by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

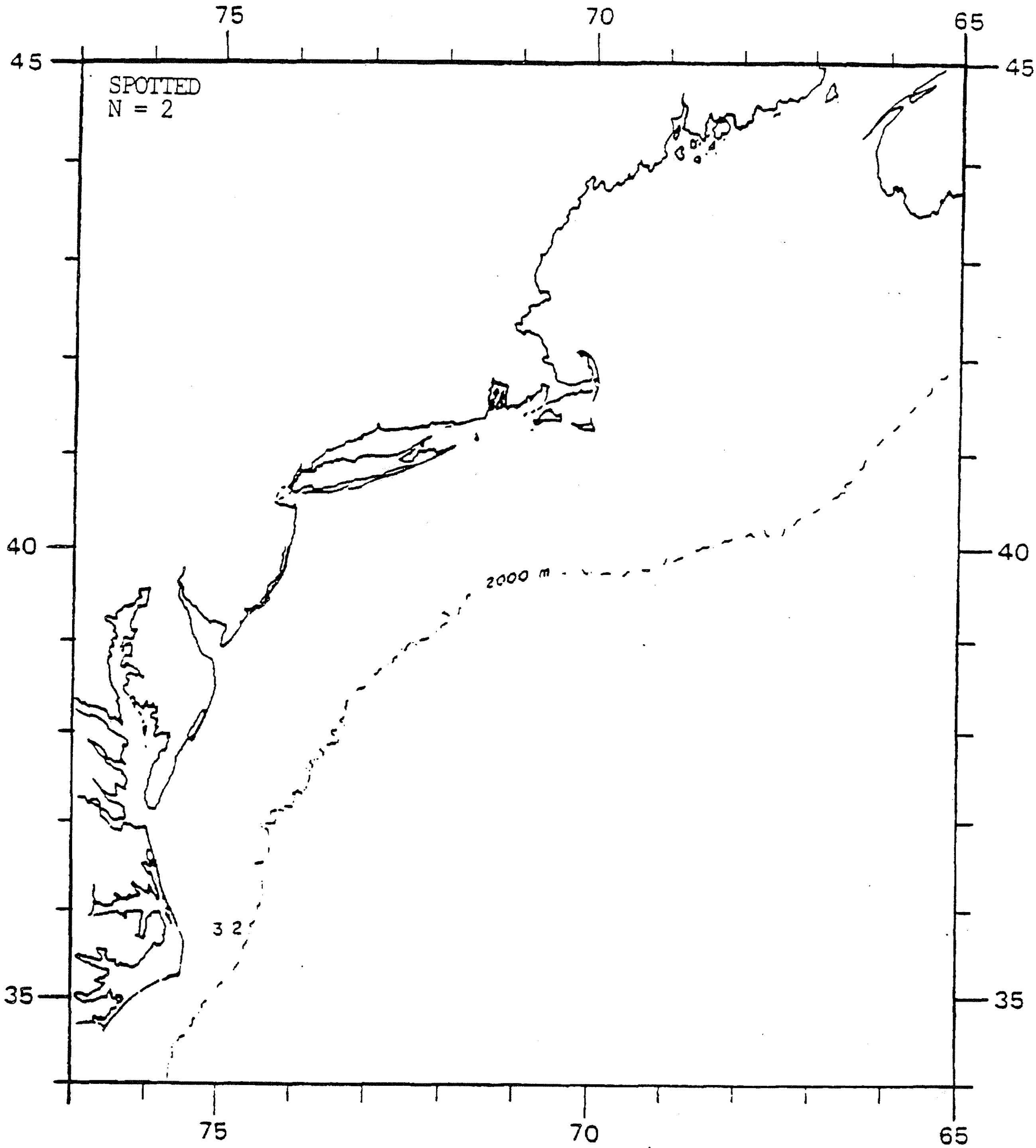

Figure 24e. Locations of sightings of feeding or apparent feeding of *Stenella* spp. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

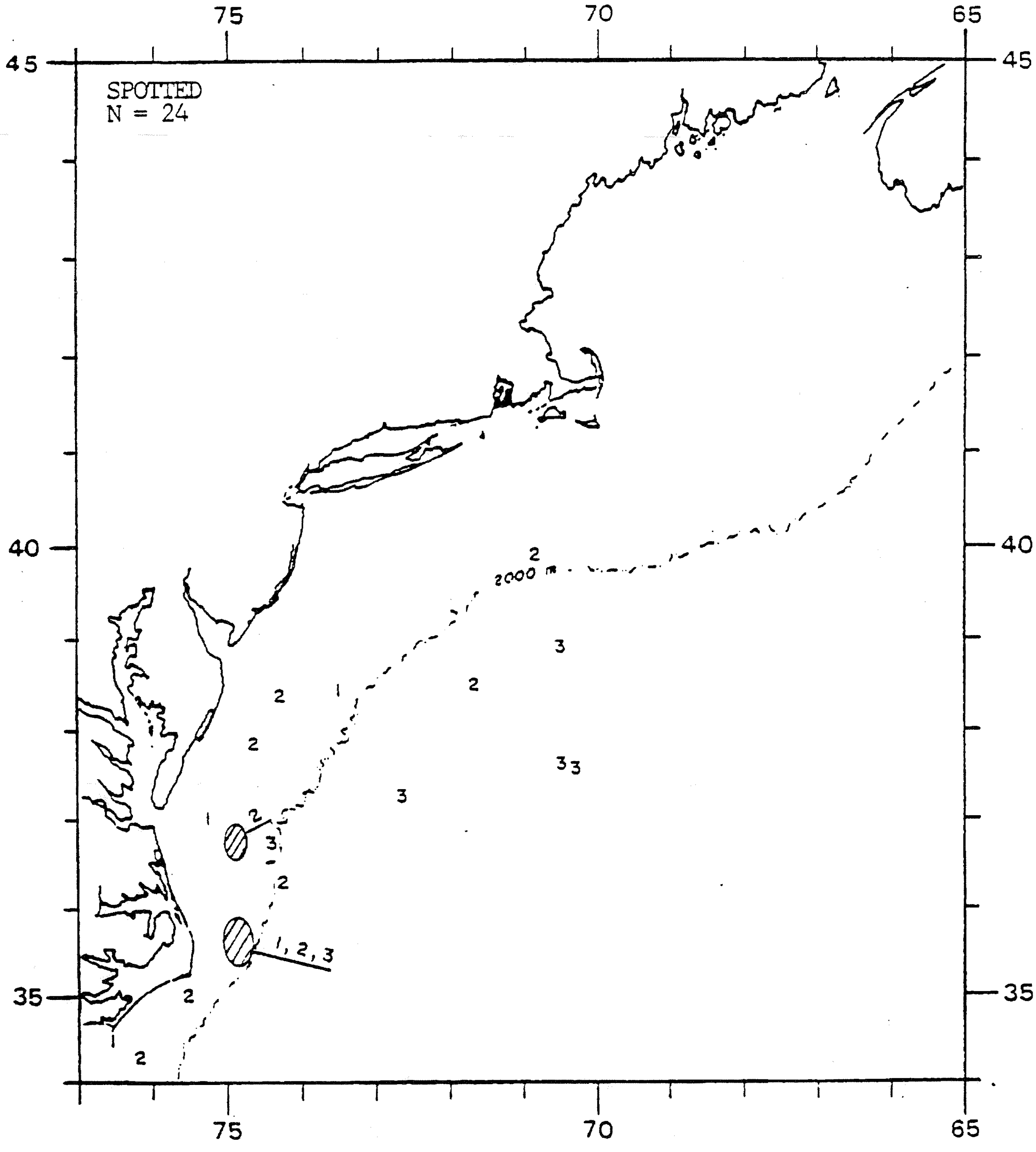

Figure 24f. Sightings of calves or juveniles of Stenella spp. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

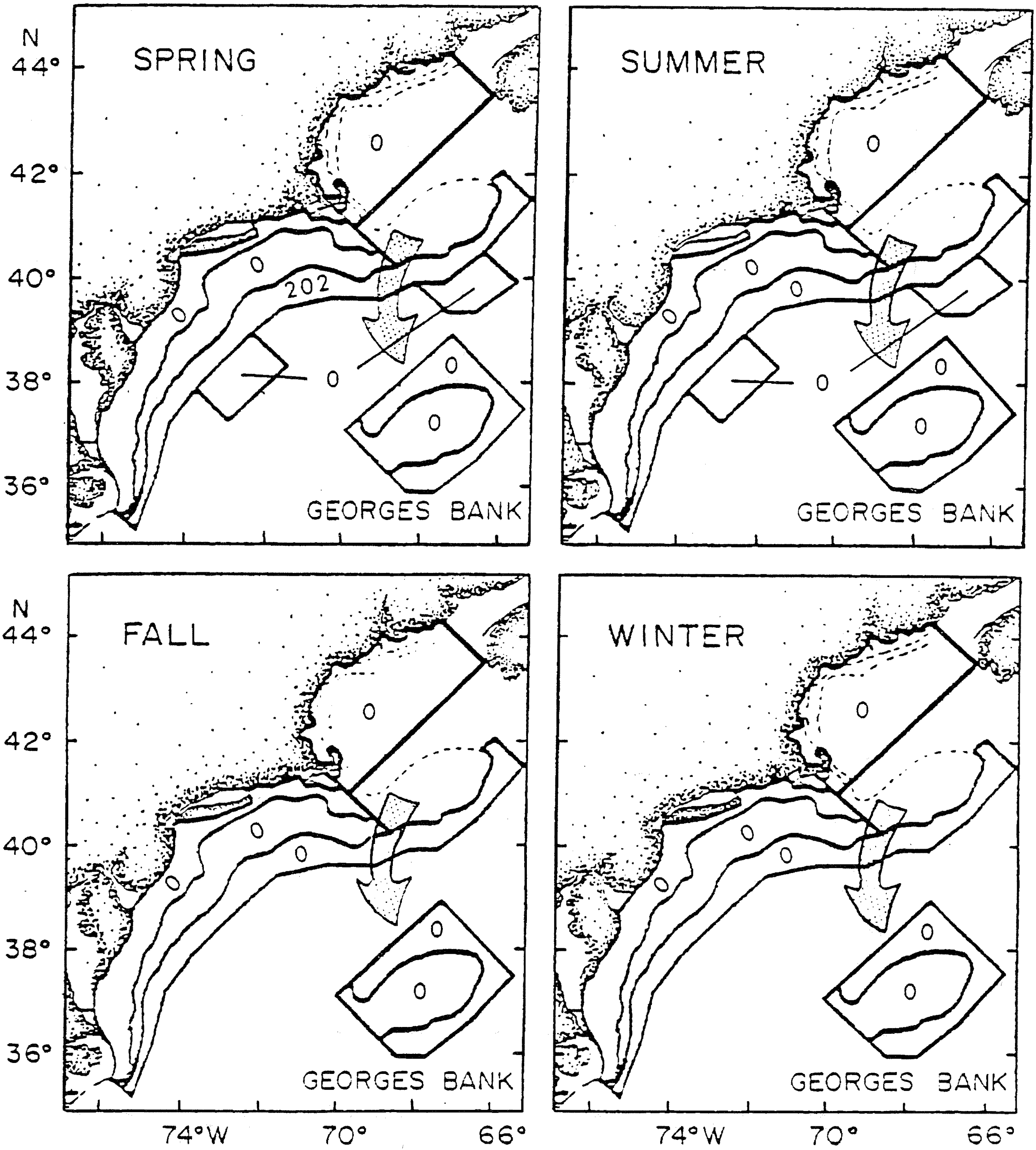

Figure 24g. Estimates of the number of individuals of Stenella spp. by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 18. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Stenella* spp. (spotted).

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
GEORGES BANK	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
<50 FATHOMS	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
>50 FATHOMS	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
LEASE SALE 52	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-ATLANTIC	1.28E-03 6.68E-05 176 ± 271	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEAR SHORE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-SHELF	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEW YORK BIGHT	3.17E-03 1.65E-04 196 ± 328	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
SHELF EDGE	3.26E-03 1.69E-04 202 ± 313	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
CONTINENTAL SLOPE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	. . . ± .	. . . ± .
STUDY AREA OCS*	190 ± 291	0 ± 0	0 ± 0	0 ± 0

*Study area OCS does not include the slope water regions.

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Stenella coeruleoalba - Striped dolphin

INTRODUCTION

1981 Data. The 1981 data were consistent with those presented in the previous 1979 and 1980 CETAP Annual Reports. The small number of sightings of striped dolphins in 1981 is due largely to the discontinuation of shipboard platforms-of-opportunity at the end of 1980. This item is addressed in the presentation of the cumulative results from all years which follows below.

Number of Sightings. S. coeruleoalba was the eighth most commonly sighted small whale in the study area. The 114 sightings of 7404 individuals accounted for 3% of the small whale sightings and 2% of the odontocete sightings during the 3 year survey period.

Individuals per Sightings. The average number of individuals per sighting was 64.9, the largest for all small whale species, and also odontocetes. The mode was 20, with a range from 1 to 500.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The striped dolphin, Stenella coeruleoalba, is distributed along the shelf-edge from Cape Hatteras to the southern margin of Georges Bank, and offshore over the continental slope and rise in the Mid-Atlantic Bight region (Figures 25a-d). The shelf edge

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sightings are generally centered about the 1000 m depth contour. The three sightings which occurred in the shallower waters over the continental shelf proper were given I.D. reliabilities of either "probable" or "unsure." Therefore, the distribution of the species shoreward of the 100 m depth contour will require future confirmation. The seasonal distribution of the species sets it apart from most other cetaceans. The strong seasonal changes in distribution and abundance common to many species are not shown by striped dolphins. The relative abundance data (Figure 25d) shows that in spring there is a concentration along the shelf edge in the Mid-Atlantic Bight, and another along the shelf edge southeast of Nantucket. A striking feature of these data is a relatively high abundance of striped dolphins in the area between Hydrographer Canyon and the south central margin of Georges Bank. This area is inhabited over all four seasons, and shifts eastward in summer and fall and westward in winter and spring. One feature influencing the distributional data on this species is the difficulty in reliably identifying species within the genus Stenella from the air. This resulted in aerial sightings often classified to the genus level only, and 81 of the total 114 sightings of S. coeruleoalba were made from to shipboard platforms. Therefore, sighting platform, along with sighting effort, are both variables which influence the data collected for a number of species including the striped dolphin.

Feeding. There were only four sightings of surface feeding striped dolphins; these sightings accounted for 3.5% of the total sightings. Three of these feeding sightings were along the shelf break south of 39' N; the fourth sighting was offshore over deep slope waters in the same region (Fig. 25e). All of these sightings were made in the spring period. These sightings coincided with the major region of general striped dolphin sightings, i.e., the shelf break from Cape Hatteras to 41' N.

Striped dolphins in the Pacific waters feed primarily on mesopelagic fish and squid (Miyazake et al., 1973). Assuming Atlantic striped dolphins feed on a similar diet, the striped dolphins in the study area would be primarily sub-surface feeders, hence the few surface feeding sightings. Striped dolphins are most likely feeding over the entire range that general sightings were made.

One striped dolphin surface feeding sighting was within the region of Lease Areas 40, 49, and 59. There were numerous general sightings in Lease Areas 40, 49, 59, and Proposed Area 52. It is likely that striped dolphins feed over the shelf break throughout these areas.

Calves and Juveniles. During the three year survey period, 14 sightings of calves or juveniles were reported (Figure 25f). Calves were distributed along the edge of the continental shelf from Cape Hatteras to Long Island. This was similar to the adult distribution except that an additional concentration of adult sightings was reported outside the shelf from North Carolina to New Jersey. Most calves were seen during the spring (9 sightings). Fewer sightings were reported during the summer (2), fall (2) and winter (1).

No information is available about calving behavior among North Atlantic populations, but Kasuya (1972) reported two peaks of reproduction during spring and fall for the striped dolphin in Japanese waters (see Katona et al., 1978). The reason for the apparent peak in calf sightings during the spring is unknown, but it may be an artifact of the increased survey effort during that time.

Calves were found among adult groups ranging in size from 10 to 500 animals. Most groups contained more than 100 animals.

A few calves were sighted within Lease Sale Areas 40, 49, and 59, and within Proposed Lease Sale Area 52 during the spring and fall.

Areas. S. coeruleoalba occurs in the Mid-Atlantic Lease Sale Areas (40, 49, 59) at low to moderate levels. The sightings are widely scattered throughout these Mid-Atlantic areas, but are concentrated in the southern half and in the spring. A few sightings were reported in summer and fall, and only a single sighting (extreme northeast corner) was made in the winter. In winter, however, there was a concentration of sightings just outside the northeast boundary, and another concentration just outside the southwest boundary. In the North Atlantic, striped dolphins were not sighted in Lease Sale Area 42 at any time. The species is present at relatively high levels in Proposed Lease Sale 52 in spring. It is present at similar levels, but in a more restricted area, in fall and winter. In summer, sightings are located east of the Proposed Lease Sale 52 boundary, and outside of the area.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 19 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 25g. The peak average abundance of striped dolphins in the study area was 4319 (+/- 3988) and occurred during the spring. Correspondingly, the peak average abundance (4593 +/- 4296) of this species in the region defined as Shelf Edge also occurred the spring. The maximum point abundance estimate was 8446 (+/- 9103) in sampling block E in June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 12223 (+/13381) in sampling block E, stratum z, in June 1979.

Water Temperature (°C). Water temperatures were available for 29 sightings of this species. The average water temperature was 16.9°C, the sixth warmest for odontocetes, and fifth warmest for small whale species. The mode was 9.0, with a range from 8.3 to 24.8°C.

Depth (m). The average depth for *S. coeruleoalba* sightings was 2076m, the deepest for all small whale species, and also all odontocetes. The mode was 2010 with a range from 49 to 5121m. Ninety percent of these sightings were found in a wide and deep range of water depths (101 to 3749). This corresponds well with the distribution of *S. coeruleoalba* sightings concentrated along the shelf edge and also seaward of the shelf edge.

BEHAVIOR

Associations. Striped dolphins were infrequently observed (10% of total sightings) with another cetacean species. *D.delphis* was the most commonly seen species with *S.coeruleoalba* but occurred on only 5 occasions. Additional observations of one or two instances each were reported for *P.catodon*, *B.acutorostrata*, *G.griseus*, *T.truncatus*, *Stenella* spp. (spotted) and unidentified dolphins (for details, refer to Table 30. Behaviors by striped dolphins such as porpoising, aerobatics, and bow-riding were reported in 44% of multispecies sightings, representing the high activity levels often associated with play.

Migration and Movement. The present data do not support any clear conclusions on this topic. The number of sightings seaward of the 2000 m depth contour suggests the possibility of movement between the slope and rise region.

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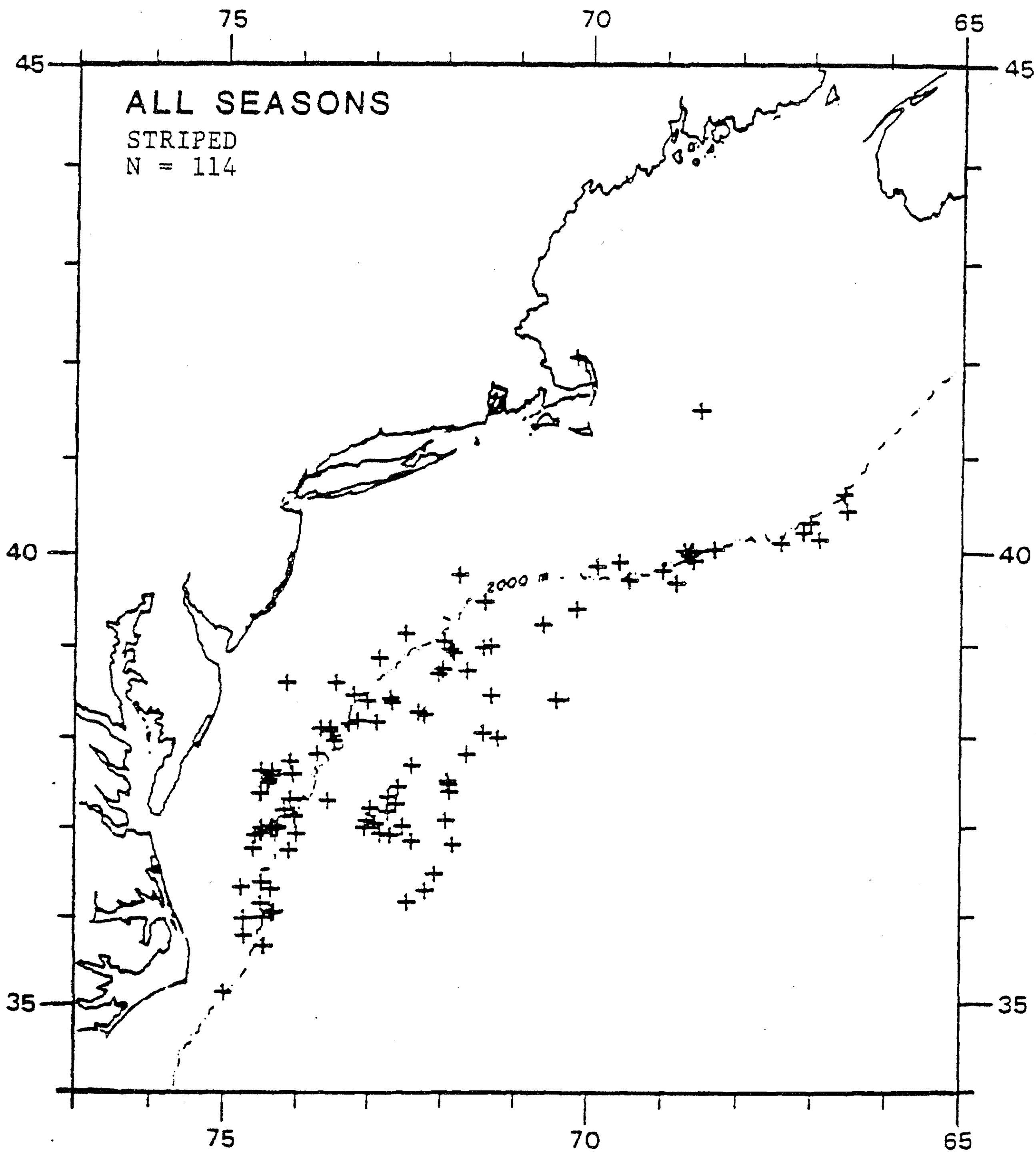

Figure 25a. All sightings of the striped dolphin, Stenella coeruleoalba, for the 39 month period -- 1 November 1978 through 28 January 1982.

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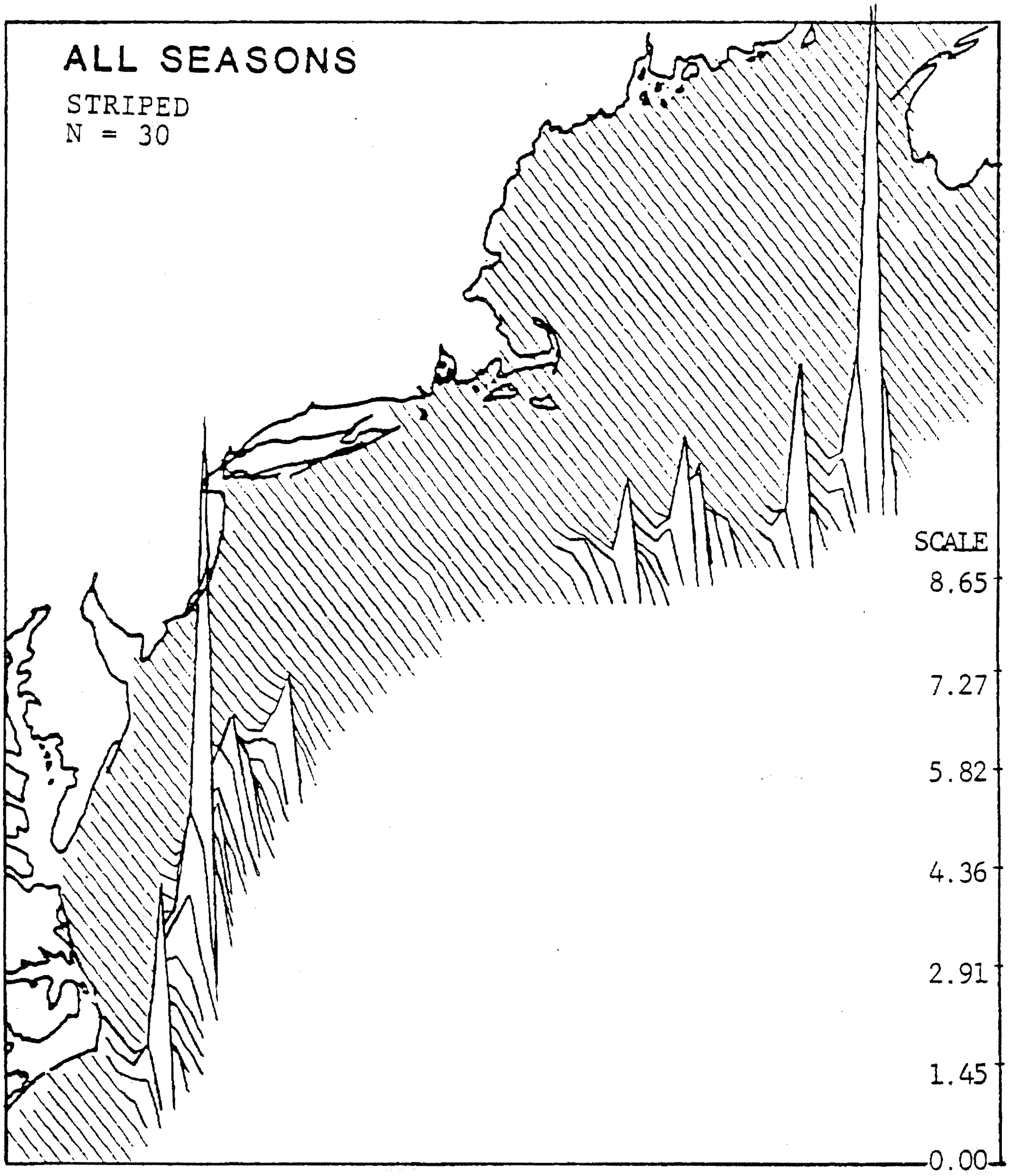

Figure 25b. The relative abundance of S. coeruleoalba for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

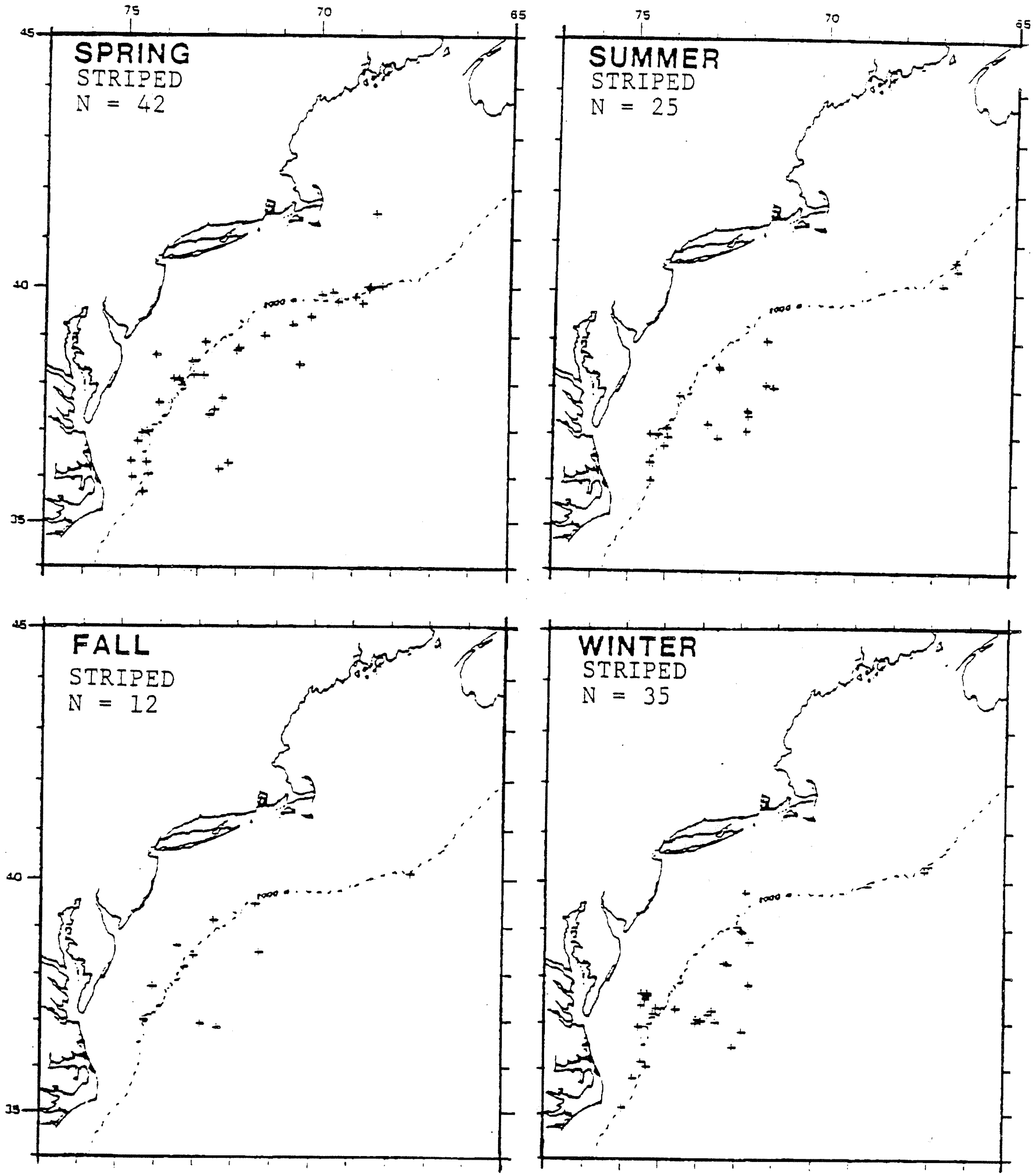

Figure 25c. The sighting distribution of S. coeruleoalba by season.

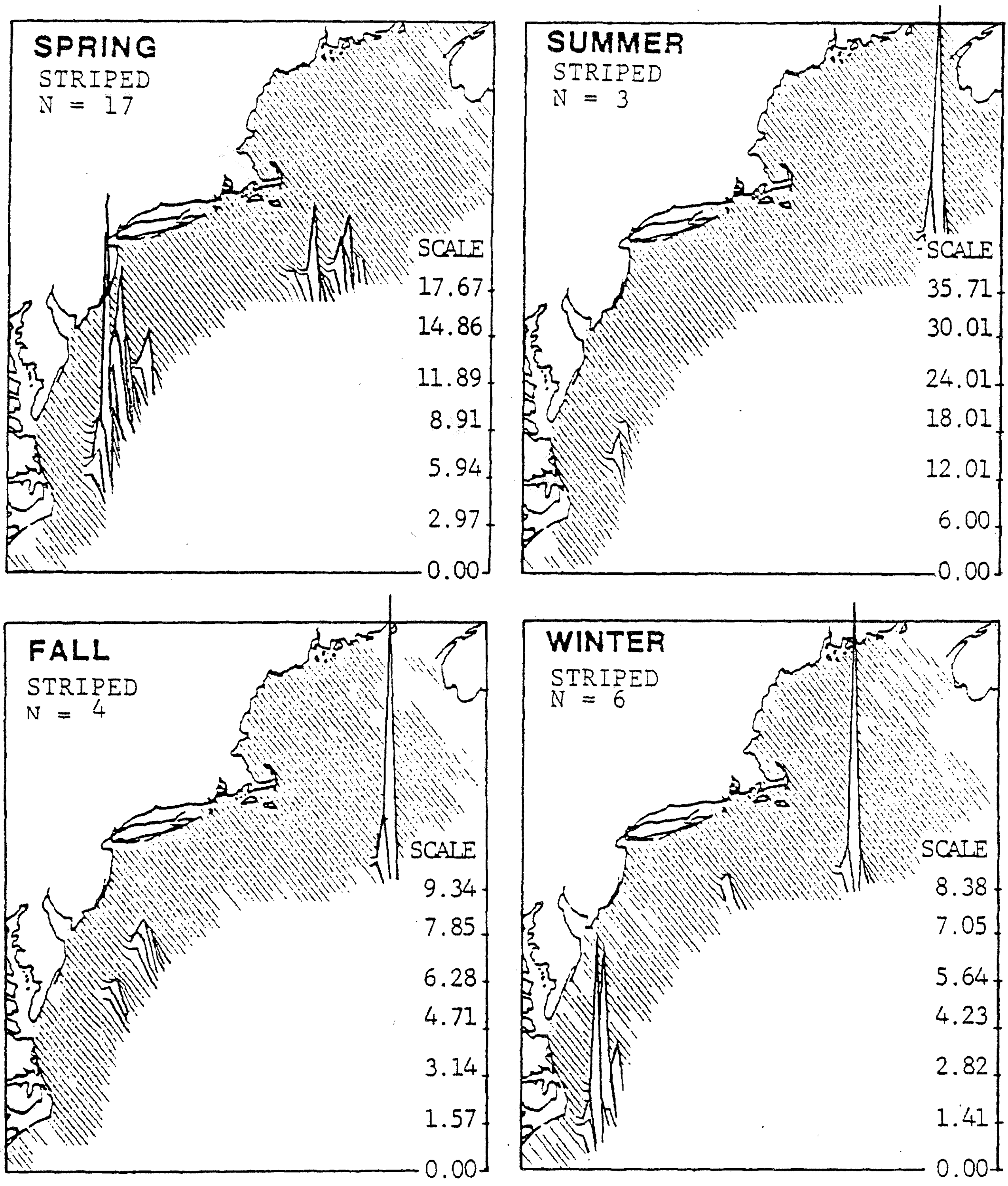

Figure 25d. The relative abundance of S. coeruleoalba by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

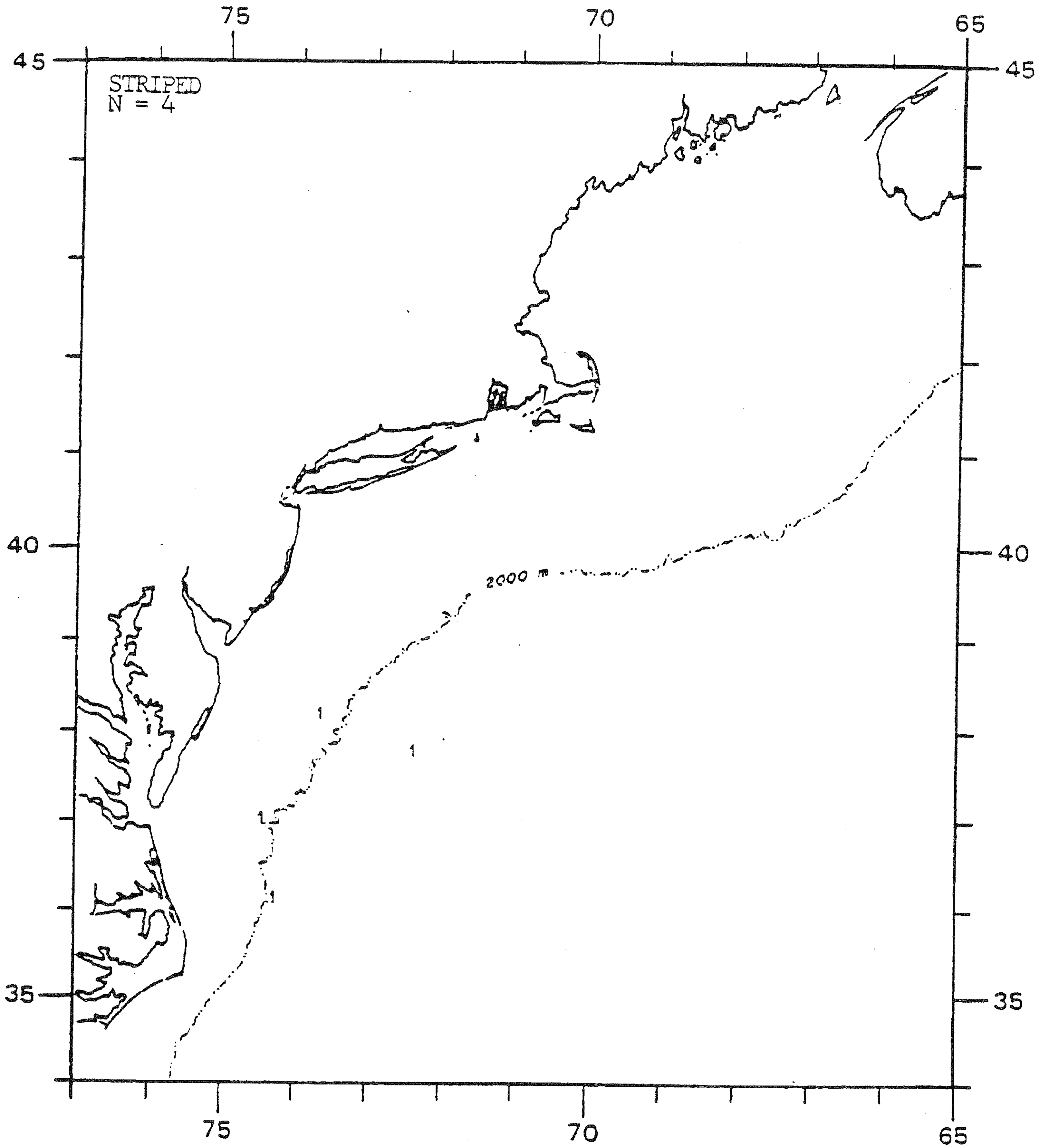

Figure 25e. Locations of sightings of feeding or apparent feeding of S. coeruleoalba. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

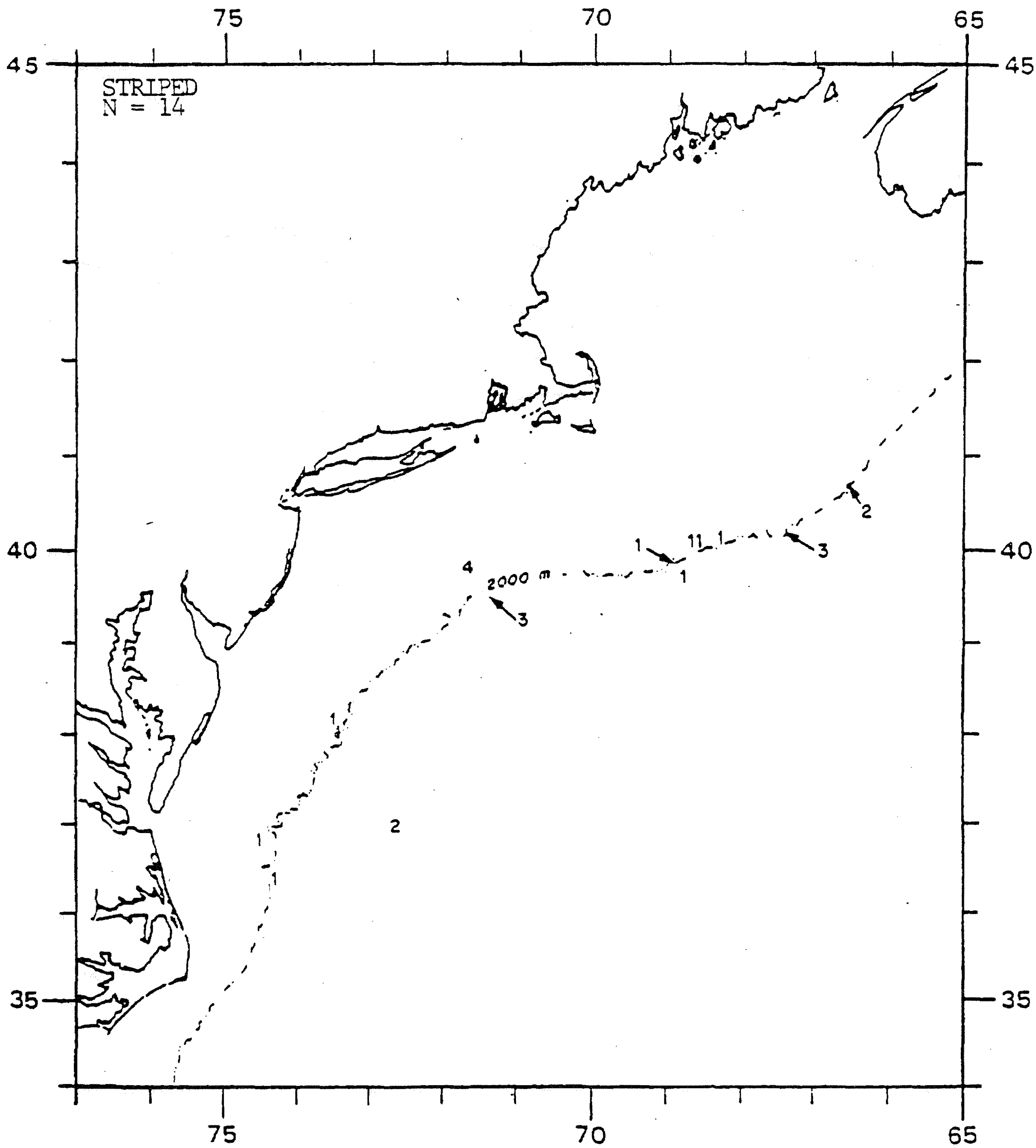

Figure 25f. Sightings of calves or juveniles of S. coeruleoalba. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

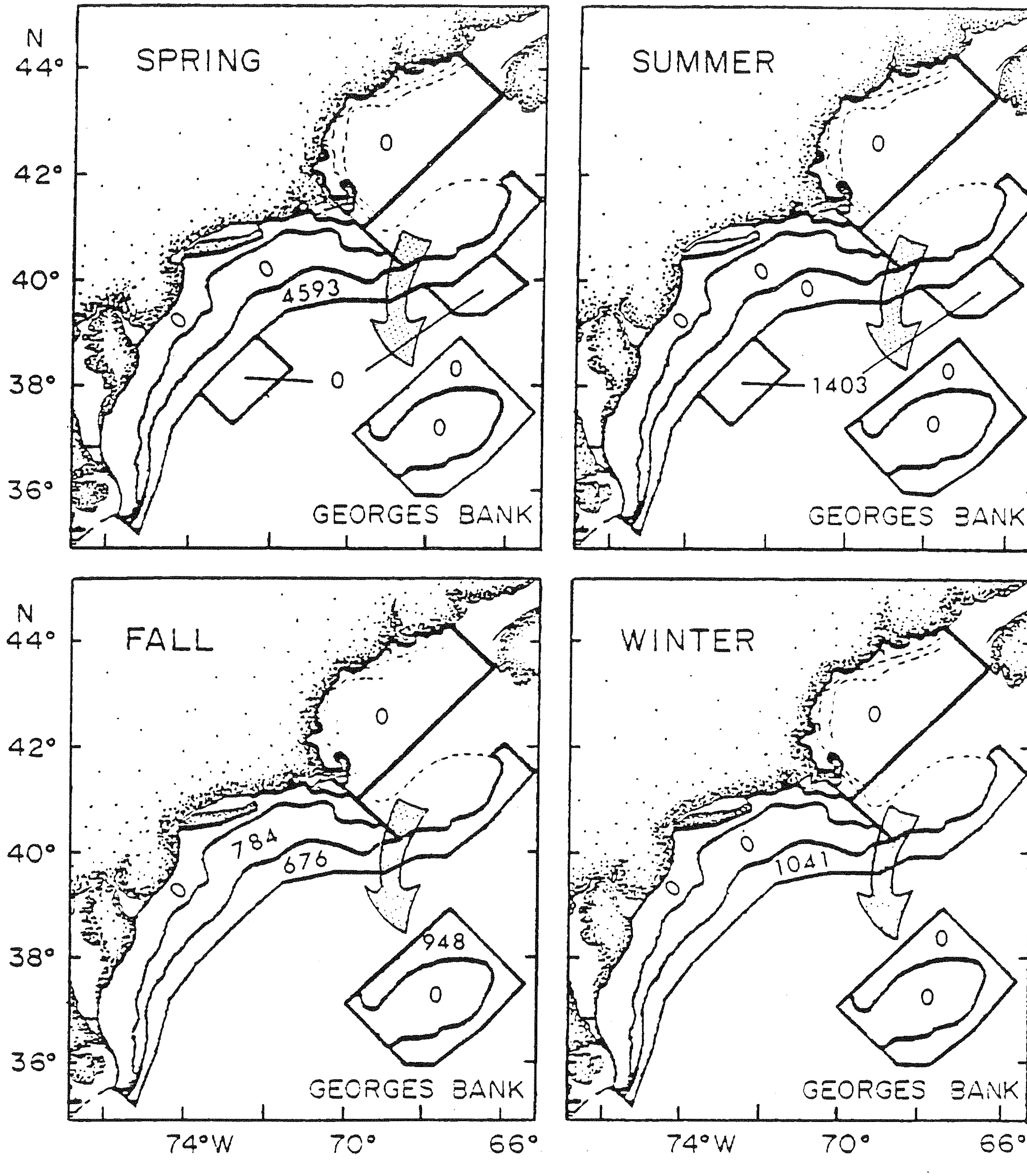

Figure 25g. Estimates of the number of individuals of S. coeruleoalba by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 19. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Stenella coeruleoalba*.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
GEORGES BANK	0.00E+00	0.00E+00	1.46E-02	0.00E+00
	0.00E+00	0.00E+00	2.24E-03	0.00E+00
	0	0	1010	0
	± 0	± 0	± 2513	± 0
<50 FATHOMS	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
>50 FATHOMS	0.00E+00	0.00E+00	2.58E-02	0.00E+00
	0.00E+00	0.00E+00	3.96E-03	0.00E+00
	0	0	948	0
	± 0	± 0	± 2866	± 0
LEASE SALE 52	8.66E-02	0.00E+00	1.97E-02	0.00E+00
	4.13E-02	0.00E+00	3.02E-03	0.00E+00
	2414	0	550	0
	± 2912	± 0	± 1609	± 0
MID-ATLANTIC	2.92E-02	0.00E+00	5.40E-03	6.03E-03
	1.25E-02	0.00E+00	1.49E-03	1.70E-03
	4002	0	741	828
	± 3710	± 0	± 1585	± 1434
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	0.00E+00	0.00E+00	1.50E-02	0.00E+00
	0.00E+00	0.00E+00	4.15E-03	0.00E+00
	0	0	784	0
	± 0	± 0	± 1867	± 0
NEW YORK BIGHT	9.79E-03	0.00E+00	1.09E-02	1.20E-02
	3.17E-03	0.00E+00	3.01E-03	3.14E-03
	607	0	675	745
	± 1442	± 0	± 1749	± 1674
SHELF EDGE	7.40E-02	0.00E+00	1.09E-02	1.68E-02
	3.18E-02	0.00E+00	1.67E-03	4.74E-03
	4593	0	676	1041
	± 4296	± 0	± 1533	± 1849
CONTINENTAL SLOPE	0.00E+00	4.55E-02	.	.
	0.00E+00	6.30E-03	.	.
	0	1403	.	.
	± 0	± 22006	± .	± .
STUDY AREA OCS*	4319	0	1509	925
	± 3988	± 0	± 2373	± 1601

*Study area OCS does not include the slope water regions.

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Stenella longirostris - Spinner dolphin

INTRODUCTION

1981 Data. *S. longirostris* was seen on two occasions during 1981, bringing the total to 4 sightings for the 3 year survey period.

Number of Sightings. *S. longirostris* was sighted on 4 occasions (170 individuals). This accounted for less than 1% of all odontocetes and all small whale sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 42.5, the fourth largest for all odontocetes and all small whale species. However, these results were based on only 4 sightings. The mode was 35, with a range from 35 to 50.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *S. longirostris* was sighted twice during 1979, seaward of the OCS edge, east of Maryland (April sighting) and North Carolina (August sighting). During 1981, two sightings were reported during August along the 2000 m depth contour east of southern New Jersey. Figure(26a) shows the locations of these sightings.

All sightings were at or beyond the 2000 m depth contour. Therefore the species appears to be primarily deep water and southern in its distribution, and only rarely occurs in the present study area.

Feeding. Feeding was not observed in any of the sightings of *S. longirostris*, however, like other odontocetes, sub-surface feeding is presumed to occur.

Calves and Juveniles. During the three year survey period, only one sighting of calves or juveniles was reported; a mother/calf pair was seen among a group of 35 animals along the shelf edge east of New Jersey on August 2, 1981 (Figure 26b).

No information is available about the reproductive biology of spinner dolphins in the western North Atlantic.

This calf sighting was located close to, but not within, Proposed Lease Sale Area 52.

Areas. No sightings were found within Lease Sale Areas 40, 49, and 59 or 42. The two 1981 sightings were found along the southwestern edge edge of Proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. No population estimates are available for *S. longirostris* based on CETAP data.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 2 sightings of this species. Only two sightings with water temperature information were available; a water temperature of 24.5'C was recorded for both sightings.

Depth (m). Based on only 4 sightings, the average depth was 2638m, with a mode of 2048, and a range from 2048 to 3475m.

BEHAVIOR

Associations. *Stenella longirostris* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient data.

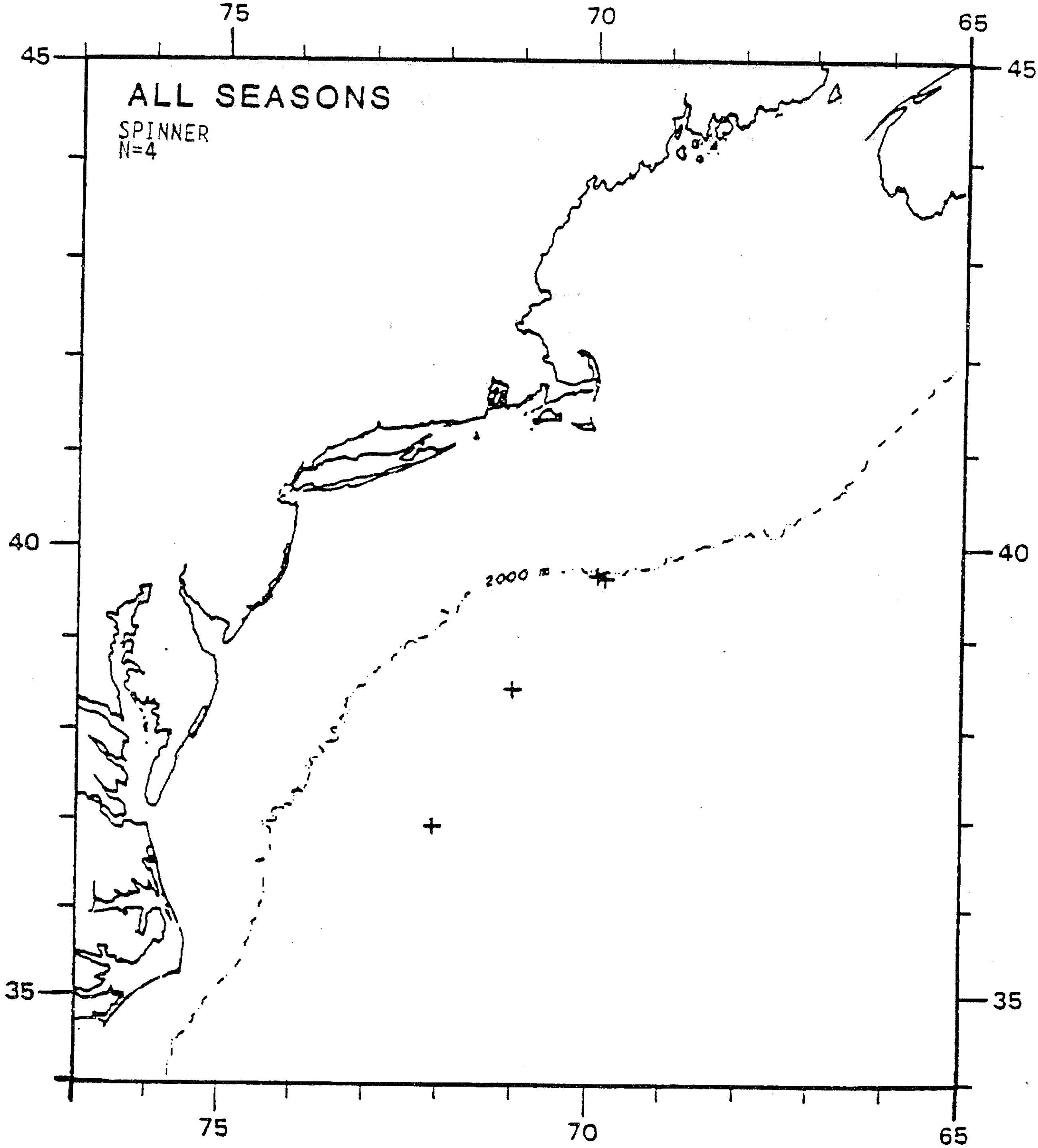

Figure 26a. All sightings of the spinner dolphin, Stenella longirostris, for the 39 month period -- 1 November 1978 through 28 January 1982.

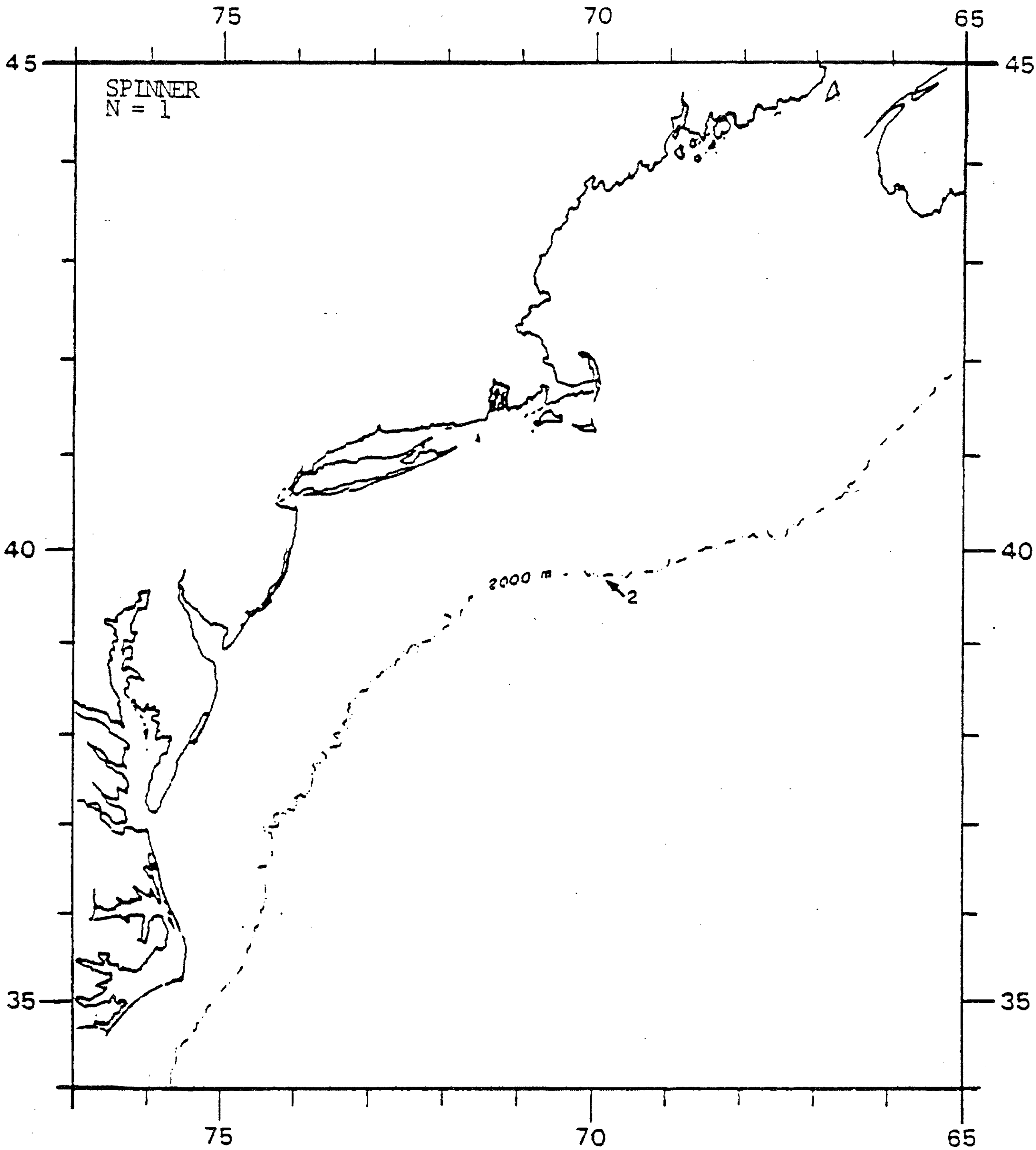

Figure 26b. Sightings of calves or juveniles of S. longirostris. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

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Mesoplodon spp. - Beaked whale

INTRODUCTION

Taxonomy and Identification. Based primarily on the examination of stranded specimens, four species within the genus Mesoplodon are known from the western North Atlantic (Leatherwood et al., 1976). However, identification to the species level is extremely difficult. Therefore, CETAP continues with the practice of referring to all sightings as grouped within the category Mesoplodon spp.

1981 Data. The 1981 data were consistent with that of 1979 and 1980. The cumulative results from all years are given in the section below.

Number of Sightings. Mesoplodon spp. were sighted on 13 occasions (39 individuals) during the 3 year survey period. This accounted for less than 1% of odontocete sightings and less than 1% of small whale sightings.

Individuals per Sighting. The average number of individuals per sighting was 3.0, the fourth smallest for odontocetes and also for small whale species. The mode was 2, with a range from 1 to 6.

General Distribution. The biology and distribution of *Mesoplodon* spp. still remains something of an enigma. Strandings of *Mesoplodon* spp. have been reported from Newfoundland, Nova Scotia, nearly the entire East Coast of the U.S., and southward to Florida and the Gulf of Mexico (Katona et al., 1978; Sergeant and Fisher, 1957; Schmidly, 1981). This suggests a widespread distribution. The CETAP sighting data, shown in Figures 27a-b, indicate a distribution along the shelf edge and over the continental slope and rise, with emphasis on the southern margin of Georges Bank. However, of the 13 sightings of this genus, 12 were assigned I.D. reliabilities of "probable." Only a single sighting of 4 individuals on 13 August 1980 north of Block Canyon, at a water of depth 1234 m, was listed as "sure." Therefore, a great deal remains to be learned about *Mesoplodon* spp. in and near the study area.

Based on the present data, little can be said about seasonal distributions. Most sightings were made in May, July, and August, with one each in March and June. Because of the interaction of reduced sighting effort and presumed rarity in the study area, no inferences should be drawn about winter distribution or overall changes in distribution with season.

Feeding. Feeding was not observed in sightings of *Mesoplodon* spp.

Calves and Juveniles. During the three year survey period, only one sighting of calves or juveniles was reported; a mother/calf pair was found along the edge of the continental shelf east of Long Island on May 29, 1980 (Figure 27c). The scarcity of calf sightings is not surprising since *Mesoplodon* adults were seen only 13 times during the entire CETAP survey.

No information is available about *Mesoplodon* reproductive biology.

The calf sighting was found within Proposed Lease Sale Area 52.

Areas. To date, no sightings of *Mesoplodon* spp. have been reported from the Mid-Atlantic Lease Sale Areas (40, 49, 59). There was one sighting close to (<10. n mi) the northeastern boundary of Lease Sale 59. In the North Atlantic, there were no sightings reported from Lease Sale 42. There were two sightings in the south central portion of Proposed Lease Sale 52. There were also two additional sightings close to (<10 n mi) the eastern boundary of Proposed 52. In summary, individuals within the genus *Mesoplodon* have not been reported from Lease Sale Areas 40, 42, 49, and 59. They are rare or occasional inhabitants of Proposed Lease Sale 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence intervals about the mean are presented in Table 20 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 27d. The peak average abundance of beaked whales in the Study Area was 121 (+/- 169) and occurred during the summer. Correspondingly, the peak average abundance of this genus in the region defined as Shelf Edge (111 +/- 163) also occurred during the summer. The maximum point abundance estimate was 214 (+/- 173) in sampling block E, stratum z, in July 1980. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. These estimates are undoubtedly conservative due to animal diving behavior and other factors.

Water Temperature (°C). Water temperatures were available for 9 sightings of this species. The average water temperature was 20.0°C, the second warmest for all odontocetes and also all small whale species. The mode was 18.0, with a range from 15.6 to 25.5°C.

Depth (m). The average depth for *Mesoplodon* spp. sightings was 2074, the second deepest for all odontocetes, and also all small whale species. The mode was 2012, with a range from 1234 to 3109m.

BEHAVIOR

Associations. Beaked whales were not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. The present data do not support any clear conclusions on this topic.

Behavior Relative to Sighting Data. As described in the 1980 CETAP Annual Report, beaked whales consistently display brief intervals at the surface and apparent avoidance behavior at almost every sighting. This behavior has resulted in no resightings of the same individuals or groups once submergence occurs. This behavior may account in part for the small number of beaked whale sightings.

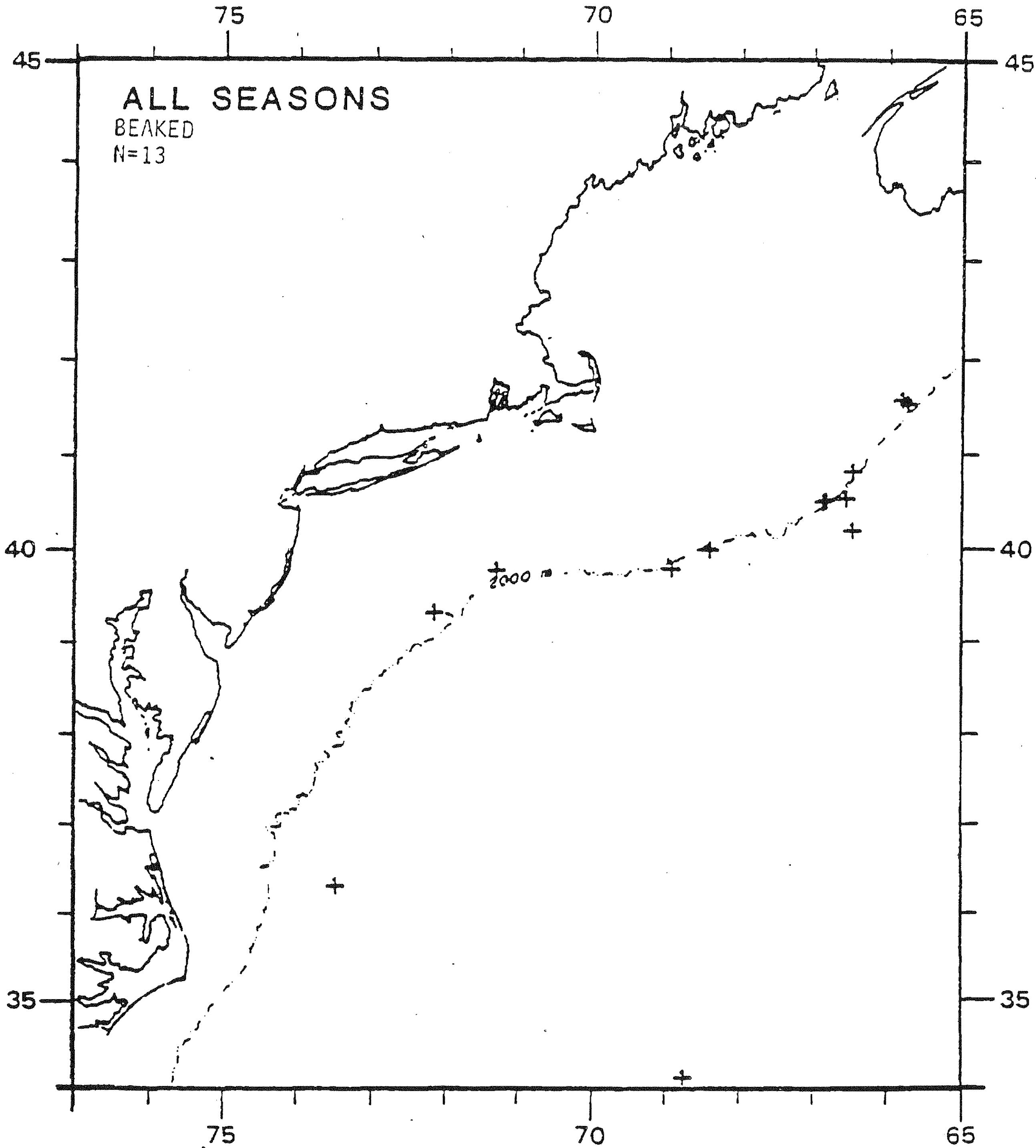

Figure 27a. All sightings of the beaked whale, Mesoplodon spp., for the 39 month period -- 1 November 1978 through 28 January 1982.

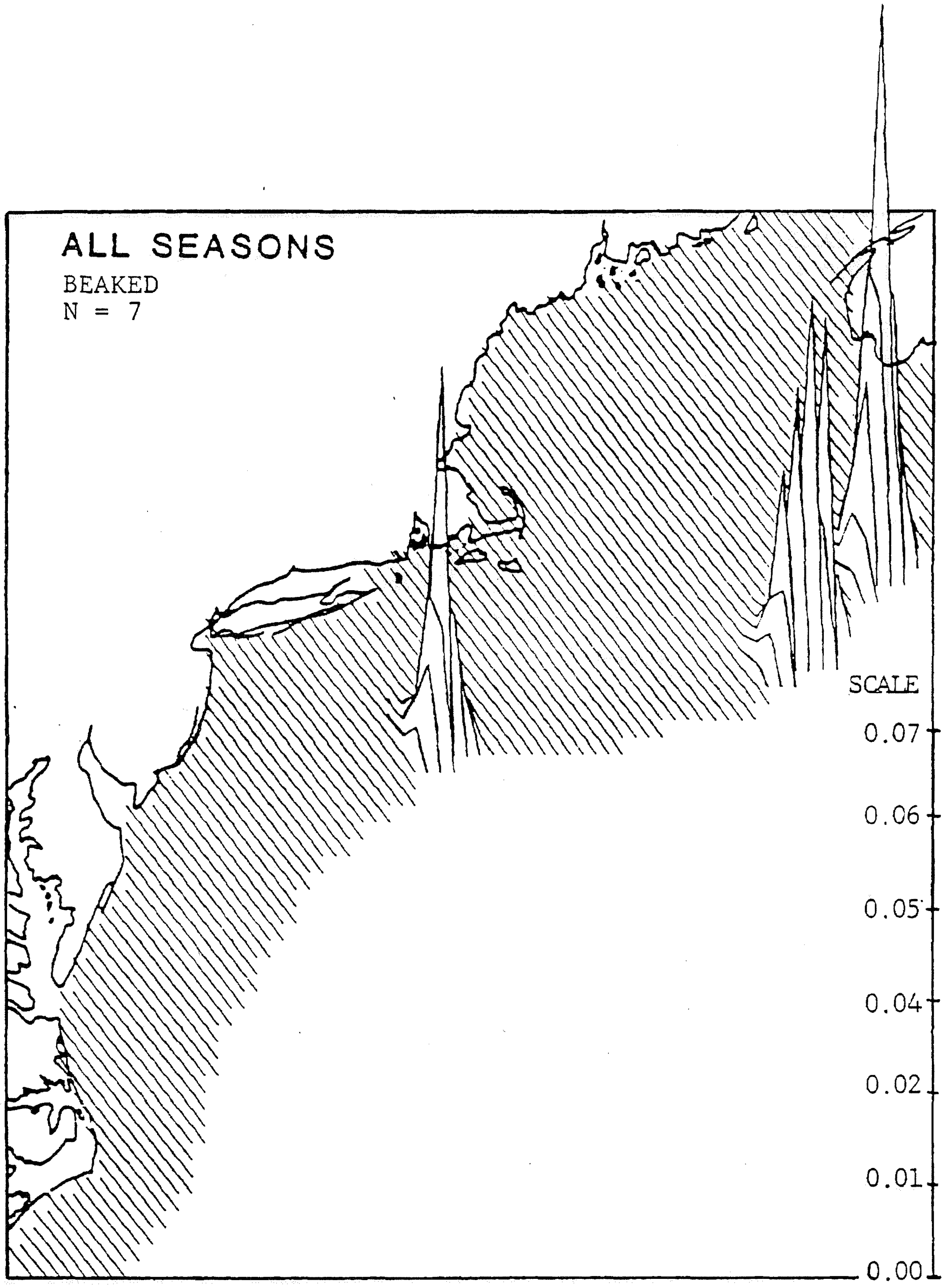

Figure 27b. The relative abundance of *Mesoplodon* spp. for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

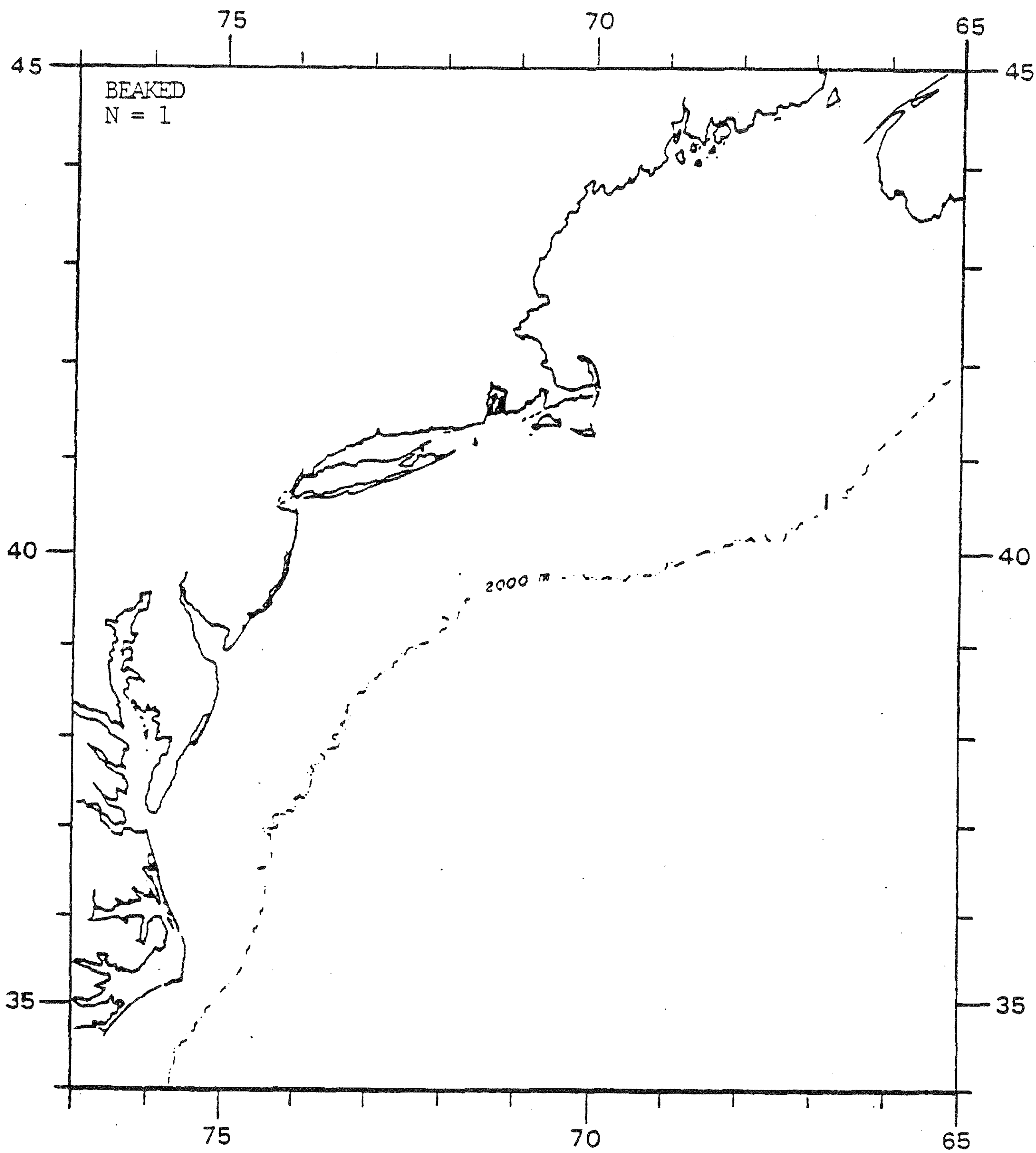

Figure 27c. Sightings of calves or juveniles of Mesoplodon spp. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

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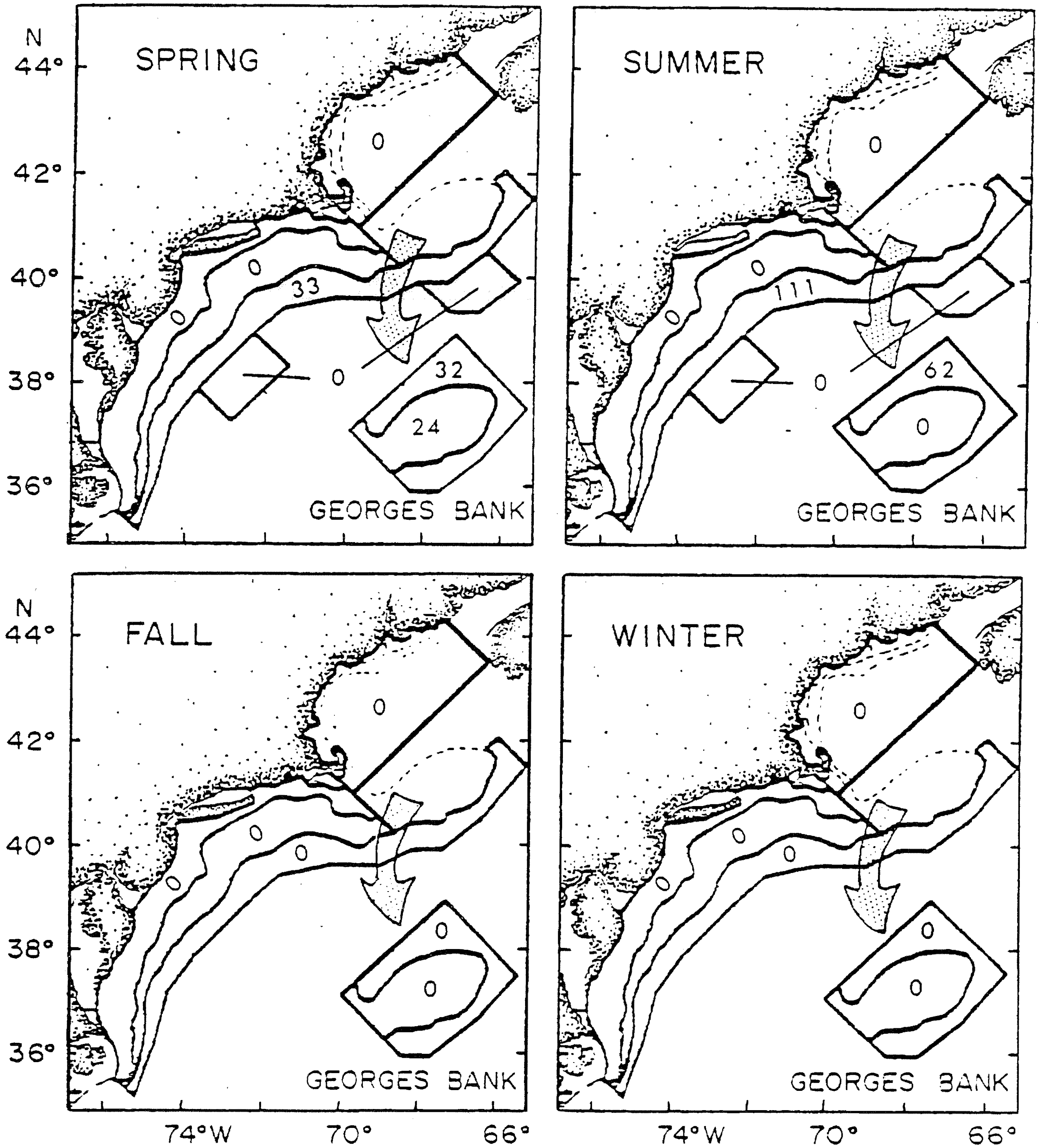

Figure 27d. Estimates of the number of individuals of Mesoplodon spp. by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

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Table 20. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for Mesoplodon spp.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
GEORGES BANK	8.01E-04	7.82E-04	0.00E+00	0.00E+00
	1.53E-05	2.16E-05	0.00E+00	0.00E+00
	55	54	0	0
	± 90	± 122	± 0	± 0
<50 FATHOMS	7.33E-04	0.00E+00	0.00E+00	0.00E+00
	1.52E-05	0.00E+00	0.00E+00	0.00E+00
	24	0	0	0
	± 65	± 0	± 0	± 0
>50 FATHOMS	8.75E-04	1.68E-03	0.00E+00	0.00E+00
	1.55E-05	4.65E-05	0.00E+00	0.00E+00
	32	62	0	0
	± 72	± 139	± 0	± 0
LEASE SALE 52	1.60E-03	1.74E-03	0.00E+00	0.00E+00
	3.08E-05	3.08E-05	0.00E+00	0.00E+00
	45	49	0	0
	± 80	± 94	± 0	± 0
MID-ATLANTIC	0.00E+00	4.22E-04	0.00E+00	0.00E+00
	0.00E+00	7.48E-06	0.00E+00	0.00E+00
	0	58	0	0
	± 0	± 102	± 0	± 0
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
NEW YORK BIGHT	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
SHELF EDGE	5.32E-04	1.79E-03	0.00E+00	0.00E+00
	9.45E-06	4.05E-05	0.00E+00	0.00E+00
	33	111	0	0
	± 74	± 163	± 0	± 0
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	60	121	0	0
	± 99	± 169	± 0	± 0

*Study area OCS does not include the slope water regions.

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Ziphius cavirostris - Goosebeaked or Cuvier's beaked whale

INTRODUCTION

1981 Data. *Z. cavirostris* was not sighted during 1981.

Number of Sightings. *Z. cavirostris* was seen only on 6 occasions (16 individuals). This accounted for less than 1% of both all odontocete and all small whale sightings.

Individuals per Sighting. The average number of individuals per sighting was 2.7, the second smallest for all odontocetes and also all small whale species. The mode was 1, with a range from 1 to 6.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. All *Z.cavirostris* sightings were found near the OCS edge (Figure 28a-b), with a latitudinal range from New Jersey to Cape Hatteras in the south. Only 1 of the 6 sightings was given an identification reliability of "sure"; all others were reported as "probable" or "unsure" sightings.

The distribution of *Z.cavirostris* presents somewhat of a puzzle. Although sightings are sparse, and almost nothing is known of its normal distribution or habits, it strands on beaches from Cape Cod south to Florida, around the Gulf of Mexico, and within the Caribbean (Katona et al.,1978; Schmidly, 1981; VanBree and Kristensen, 1974).

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The species has also been taken in a native fishery on St.Vincent, and either sighted or stranded on nearby Barbados (Caldwell et al., 1971). The correspondence of these stranding data to its actual range and distribution is not clear.

Based on these data, _Ziphius_ is an infrequent or rare inhabitant of the study area. Indications are that, if anything, it is more common in the deep ocean and/or southern waters.

Feeding. Feeding was not observed in sightings of _Z. cavirostris_.

Calves and Juveniles. During the three year survey period, only one sighting of calves or juveniles was reported; a mother/calf pair was found along the edge of the continental shelf east of Cape Hatteras on October 23, 1979.

Tomilin (1957) suggested that _Ziphius_ calves may be born predominantly in the fall (as cited in Katona et al., 1978).

This calf sighting did not fall within Lease Sale Areas 40, 42, 49, 52, or 59.

Areas. One sighting was found near the edge of Lease Sale Areas 40, 49, and 59, and another sighting was found within Proposed Lease Sale Area 52. Both sightings were assigned I.D. reliabilities of "unsure". Therefore, if it occurs in these areas at all, it is indeed a rare visitor. No sightings were found within Area 42.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence intervals about the mean, are presented in Table 21, for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 28c. The peak average abundance of Cuvier's beaked whales in the study area was 25 (+/- 47) and occurred during the summer. Correspondingly, peak average abundance estimates of 23 (+/- 46) for the Shelf-Edge, and 23 (+/- 45) for the Mid-Atlantic Bight, also occurred during the summer. The maximum point abundance estimate was 87 (+/- 71) in sampling block E, stratum z, in August 1980. Post-stratification of the 1979 data did not affect the maximum point abundance estimate.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 3 sightings of this species. The average water temperature was 24.5'C, the warmest for all odontocetes and all small whale species. The mode was 22.5, with a range from 22.5 to 27.6'C. This is consistent with its apparent offshore and southern distribution.

Depth (m). The average depth for *Z. cavirostris* sightings was 1550m, the fourth deepest for all odontocetes and third deepest for all small whale species. The mode was 59, with a range from 59 to 2707m.

BEHAVIOR

Associations. *Ziphius cavirostris* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient information.

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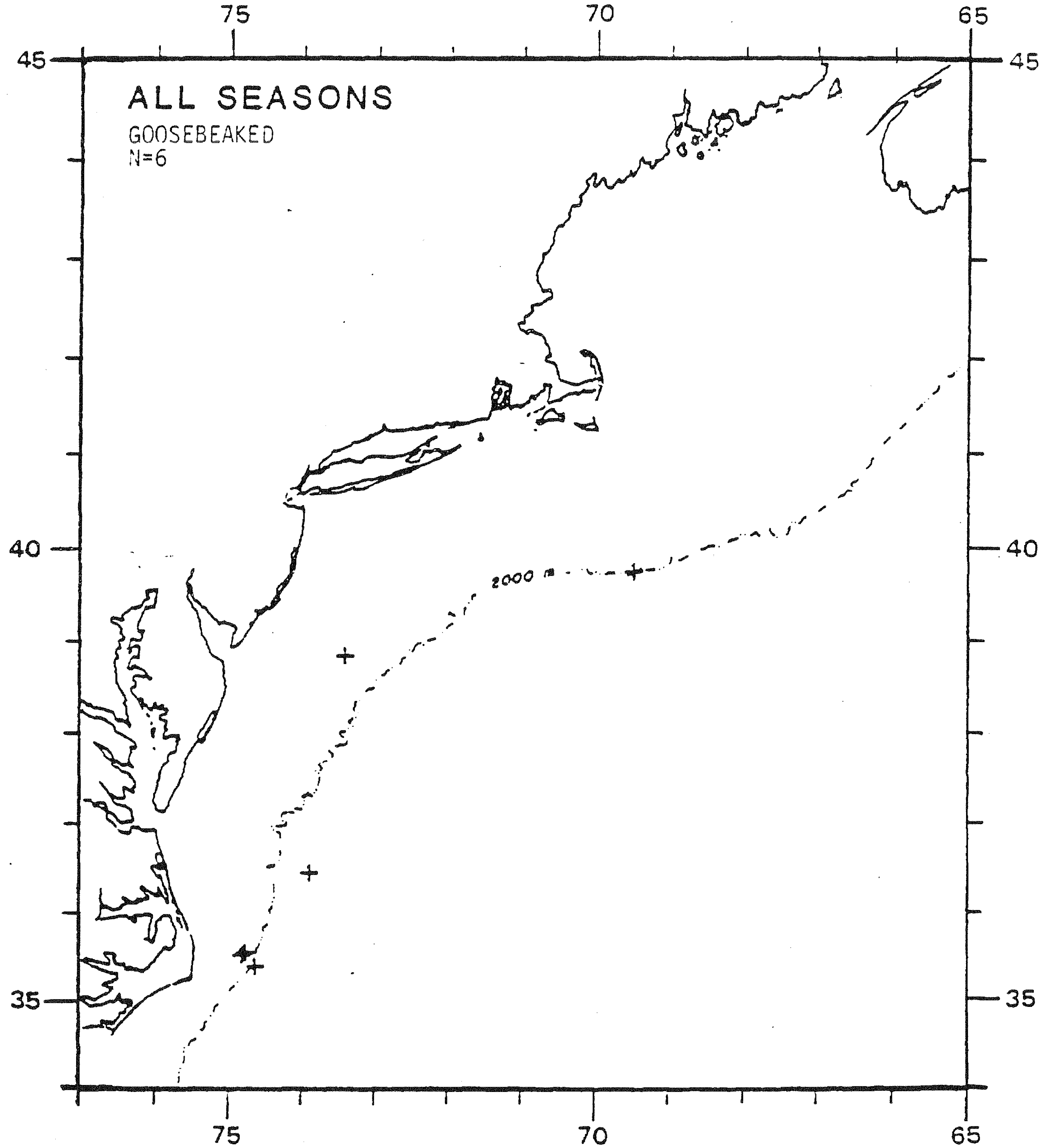

Figure 28a. All sightings of the goosebeaked whale, *Ziphius cavirostris*, for the 39 month period -- 1 November 1978 through 28 January 1982.

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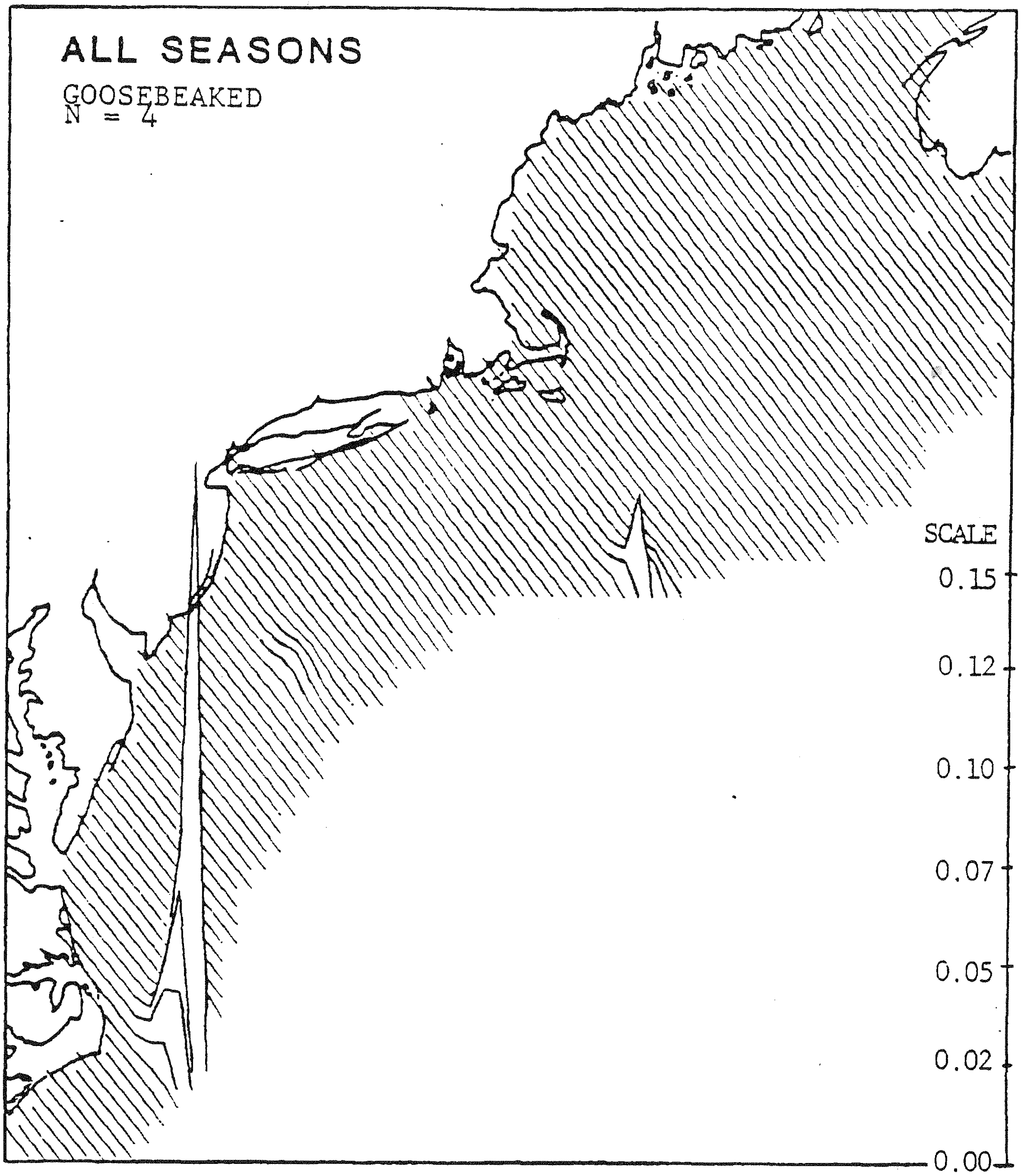

Figure 28b. The relative abundance of Z. cavirostris for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

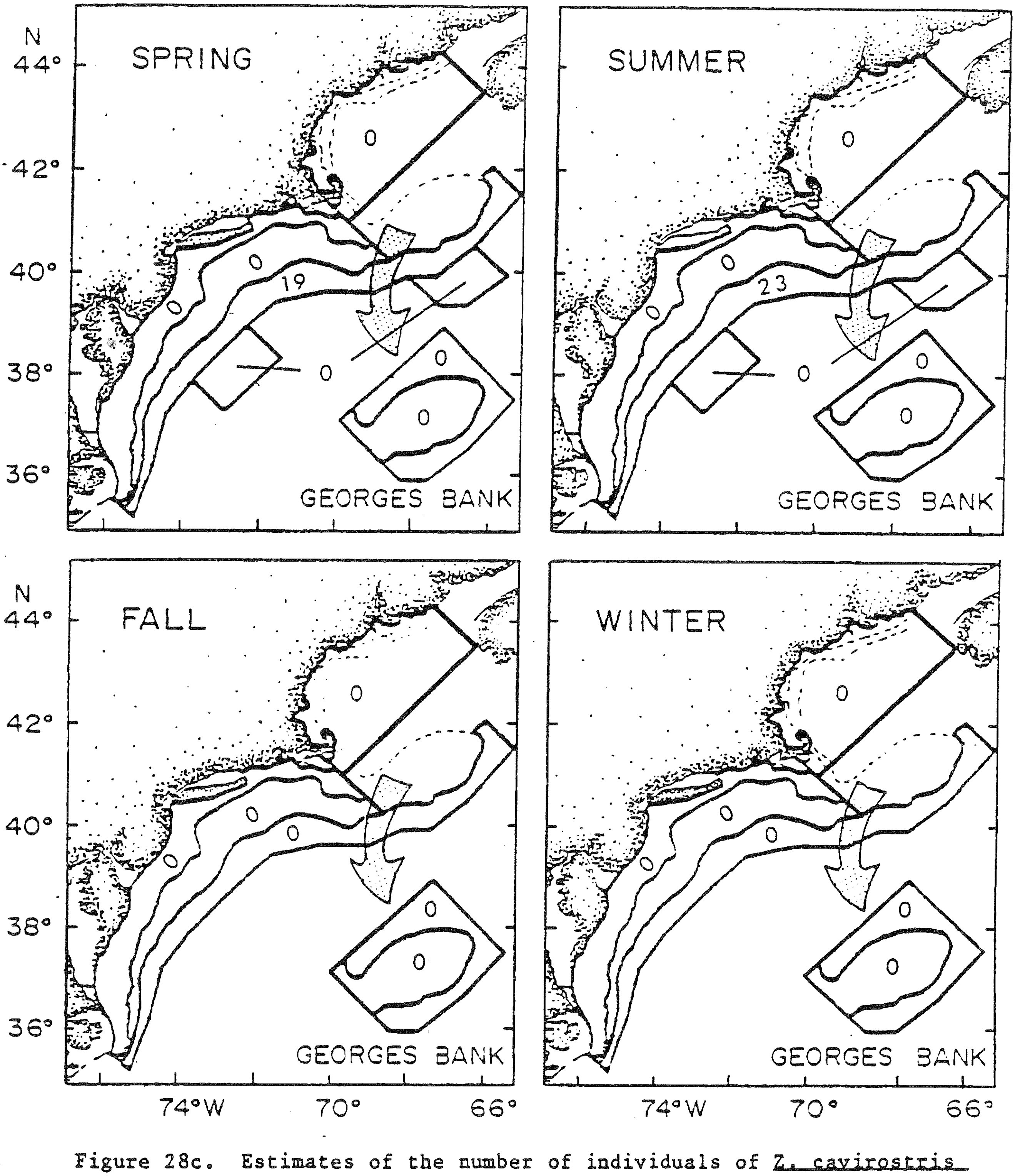

Figure 28c. Estimates of the number of individuals of Z. cavirostris by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 21. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Ziphius cavirostris*.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
GEORGES BANK	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
<50 FATHOMS	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
>50 FATHOMS	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
LEASE SALE 52	0.00E+00 0.00E+00 0 ± 0	7.05E-04 6.09E-06 20 ± 42	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-ATLANTIC	1.20E-04 3.37E-06 17 ± 61	1.71E-04 1.48E-06 23 ± 45	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEAR SHORE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
MID-SHELF	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
NEW YORK BIGHT	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
SHELF EDGE	3.05E-04 8.56E-06 19 ± 70	3.70E-04 3.19E-06 23 ± 46	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0
CONTINENTAL SLOPE	0.00E+00 0.00E+00 0 ± 0	0.00E+00 0.00E+00 0 ± 0	. . . ± .	. . . ± .
STUDY AREA OCS*	18 ± 65	25 ± 47	0 ± 0	0 ± 0

*Study area OCS does not include the slope water regions.

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Pseudorca crassidens - False killer whale

INTRODUCTION

1981 Data. No sightings were reported during 1981.

Number of Sightings. *P. crassidens* was sighted only once. This accounted for less than 1% of all odontocete and all small whale sightings.

Individuals per Sighting. Seven individuals were counted for this single sighting.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. One sighting (30 August 1980) was reported during the three year survey period along the OCS edge, southeast of Cape Hatteras (Figure 29).

Feeding. Feeding was not observed in *P. crassidens*.

Calves and Juveniles. No calves or juveniles were seen in the single sighting of this species.

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Areas. No sightings were found within Lease Sale Areas 40, 49, 59, 42, or within Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Population estimates for *P. crassidens* were not possible from CETAP data.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). A water depth of 1717 m was found at the location of the single *P.crassidens* sighting.

BEHAVIOR

Associations. *Pseudorca crassidens* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient information.

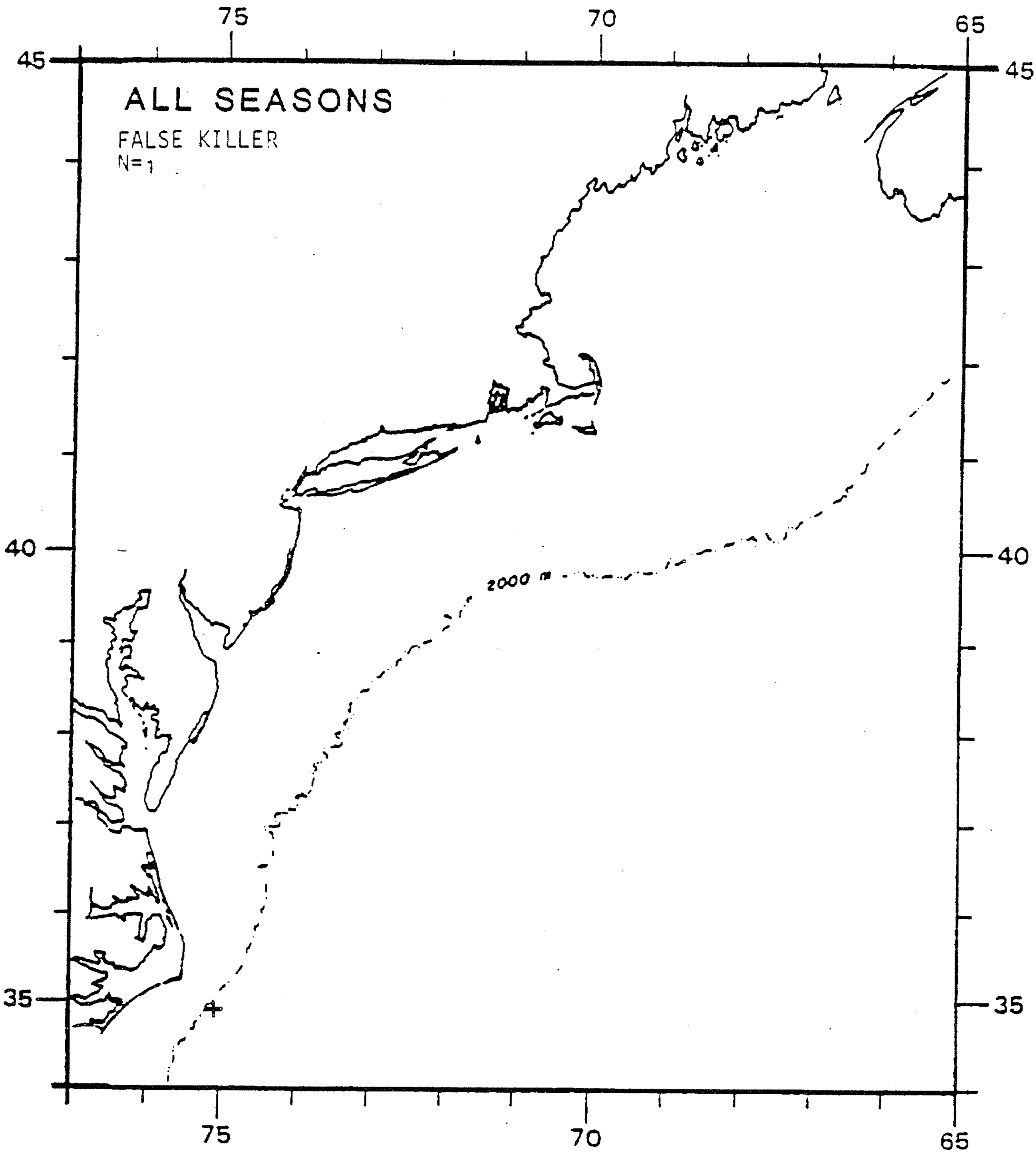

Figure 29. All sightings of the false killer whale, *Pseudorca crassidens*, for the 39 month period -- 1 November 1978 through 28 January 1982.

Feresa attenuata - Pygmy killer whale

INTRODUCTION

1981 Data. *F. attenuata* was sighted once during 1981.

Number of Sightings. *F. attenuata* was sighted only once and this was within the study area extension over the slope and rise in the North Atlantic region. This accounted for less than 1% of all odontocete and all small whale sightings.

Individuals per Sighting. Two individuals were counted for this single sighting.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. A single "unsure" sighting of 2 individuals was found on 1 August 1981, just seaward of the 2000 meter depth contour, south of Georges Bank (Figure 30).

Because of the unsure identification, the occurrence of this species in or near the study area is questionable.

Feeding. Feeding was not observed in *F. attenuata*.

Calves and Juveniles. No calves or juveniles were seen in the single sighting of this species.

Areas. No sightings were found within BLM Lease Sale Areas 40, 49, 59, 42 or Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Given that the unsure sighting was in fact *F. attenuata*, there may be a population present in the more offshore areas. Based on the one sighting, an abundance estimate of 92 (no CI) for sampling block R in August 1981 was the estimate for the pygmy killer whale.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). The depth at the single sighting was 3109m.

BEHAVIOR

Associations. *Feresa attenuata* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. No information available.

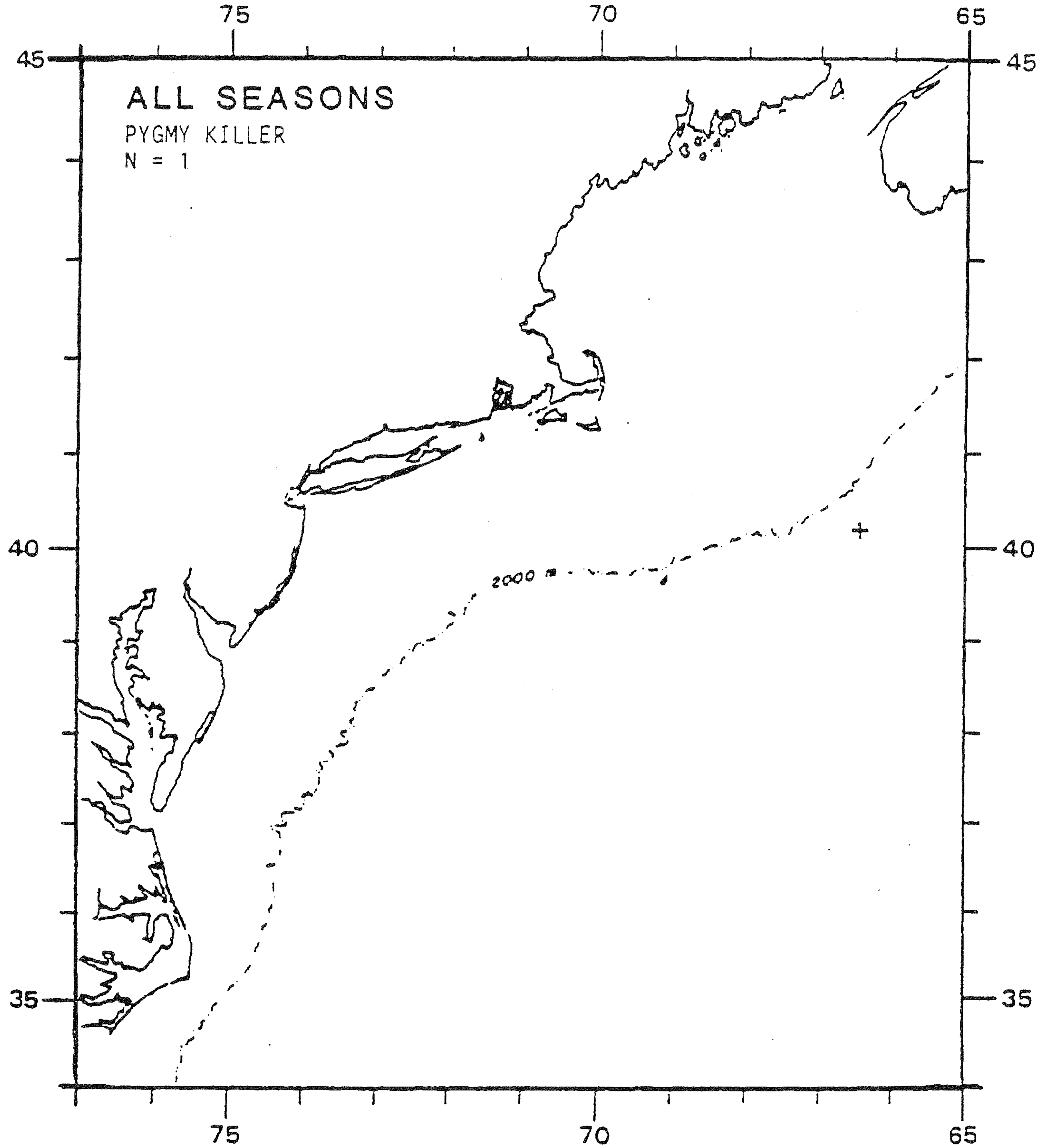

Figure 30. All sightings of the pygmy killer whale, *Feresa attenuata*, for the 39 month period -- 1 November 1978 through 28 January 1982.

Kogia spp. - Pygmy or dwarf sperm whale

INTRODUCTION

1981 Data. *Kogia* spp. was sighted once during 1981.

Number of Sightings. The two species, *Kogia breviceps* and *K. simus* were grouped into a single category, *Kogia* spp. This species grouping was sighted only once during the 3 year survey period, accounting for less than 1% of both odontocete and all small whale sightings.

Individuals per Sighting. A single individual was found at this sighting.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The only sighting was found beyond the shelf edge east of Delaware on 8 June 1981. The location of this sighting is shown in Figure 31. The I.D. reliability was "sure". An offshore distribution is indicated.

Feeding. Feeding was not observed at the single sighting of this species.

Calves and Juveniles. No calves or juveniles of *Kogia* spp. were reported.

Areas. No sightings were found within Lease Sale Areas 40, 49, and 59, or 42, or within Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Based on the one sighting, an abundance estimate of 41 (no CI) for sampling block S in June 1981 was the only population estimate.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). The depth at the sighting was 2560m.

BEHAVIOR

Associations. *Kogia* spp. was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient information.

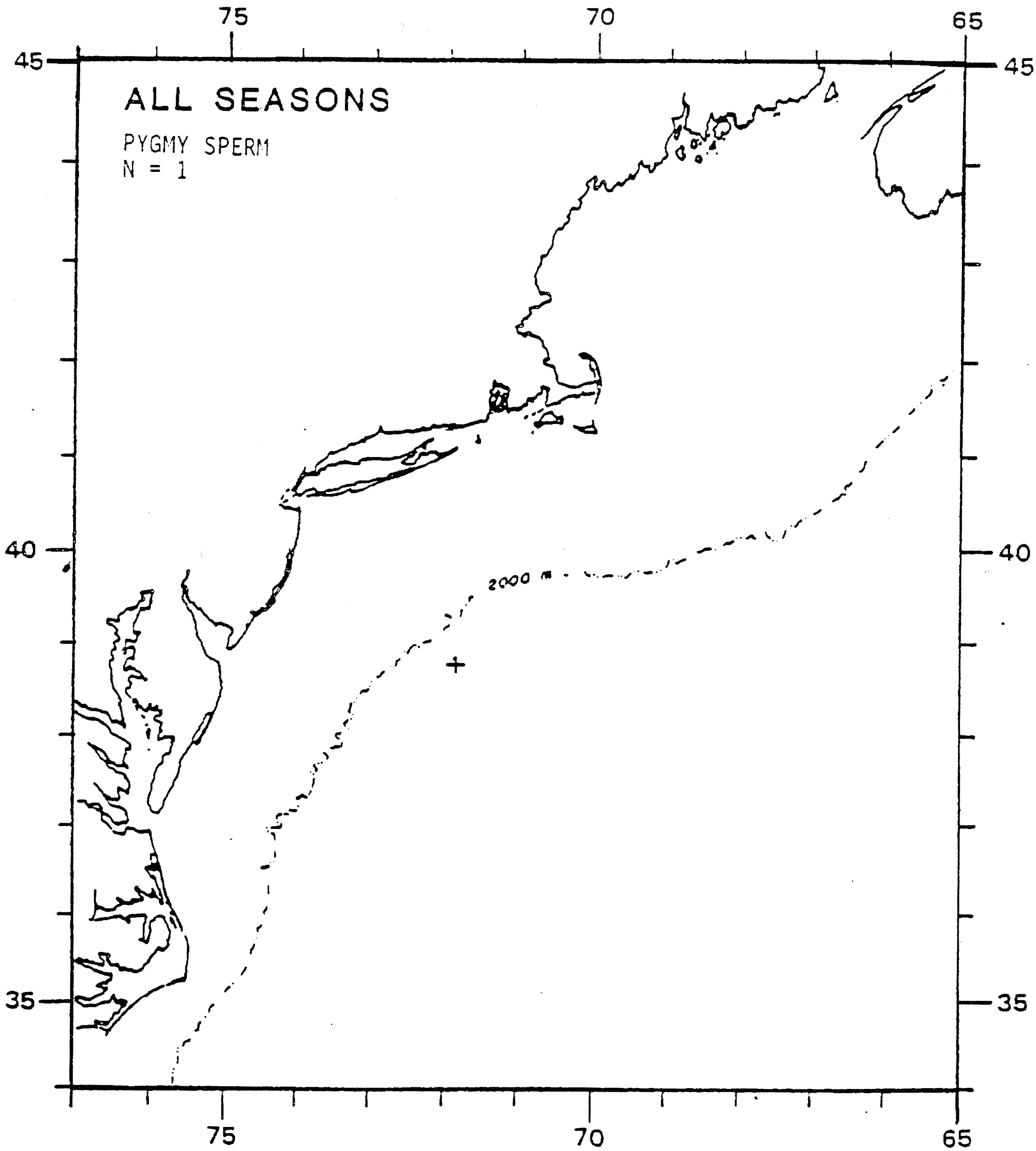

Figure 31. All sightings of the pygmy sperm whale, Kogia spp., for the 39 month period -- 1 November 1978 through 28 January 1982.

Steno bredanensis - Rough-toothed dolphin

INTRODUCTION

1981 Data. *S. bredenensis* was not sighted during 1981.

Number of Sightings. The only *S. bredanensis* sighting (45 individuals) was made outside of the study area. This accounted for less than 1% of all odontocete and all small whale sightings during the 3 year survey.

Individuals per Sighting. The one sighting included 45 individuals.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. During the 3 year survey period, *S. bredanensis* was sighted only once, on 21 September 1979. The location was south of Georges Bank, well out into the deep ocean and seaward of the OCS edge, outside of the CETAP study area (Figure 32).

Feeding. Feeding was not seen in this species.

Calves and Juveniles. No calves or juveniles of *S. bredanensis* were reported.

Areas. No sightings were found within Lease Sale Areas 40, 49, 59, 42, or Proposed Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. (See *D. leucas* account, for example)

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). A depth of 3697 m was recorded for the single sighting.

BEHAVIOR

Associations. *Steno bredanensis* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Insufficient information.

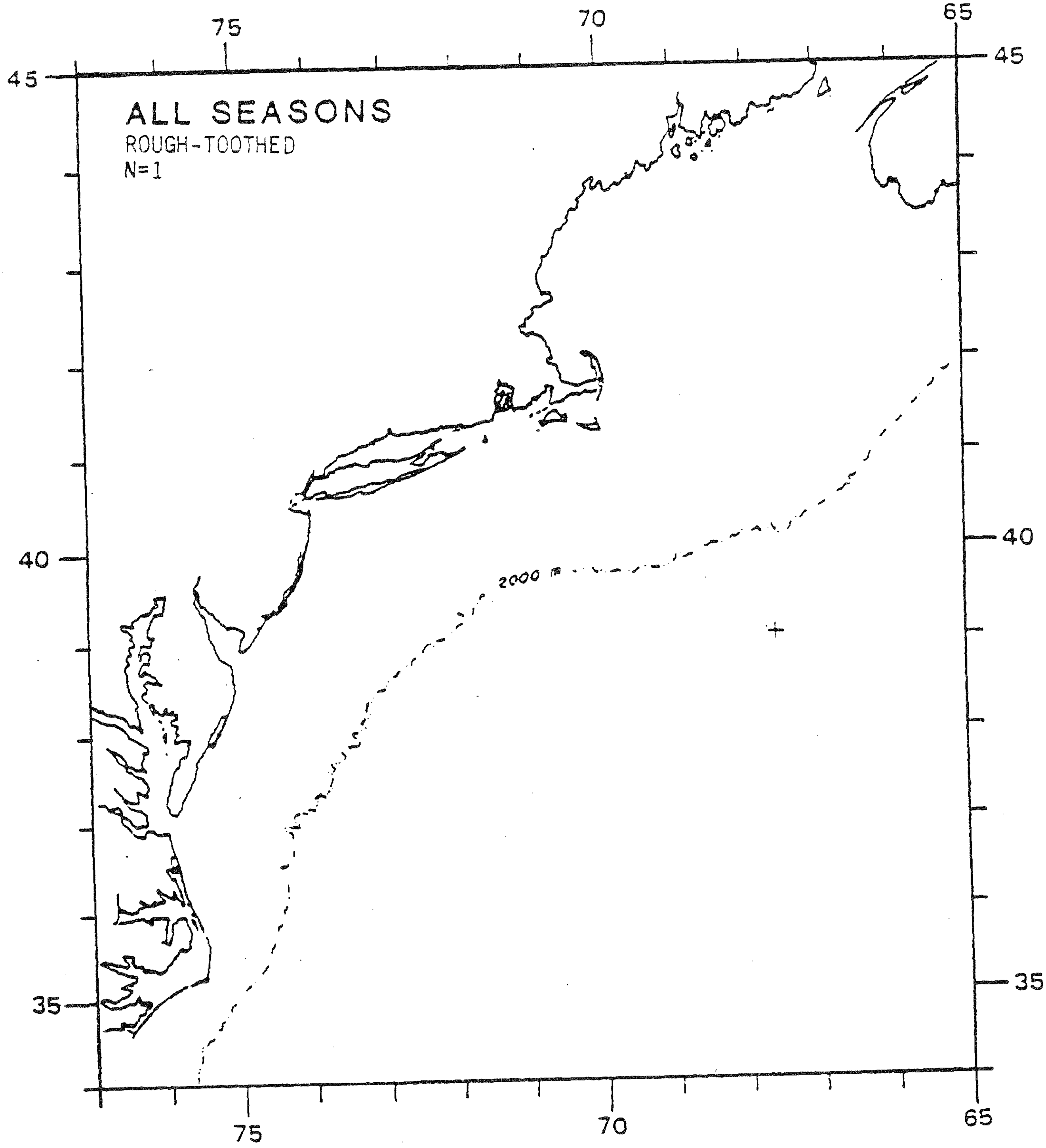

Figure 32. All sightings of the roughtoothed dolphin, <u>Steno bredanensis</u>, for the 39 month period -- 1 November 1978 through 28 January 1982.

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Delphinapterus leucas - Beluga whale

INTRODUCTION

1981 Data. No animals were sighted during 1981.

Number of Sightings. The five _D. leucas_ sightings of 7 individuals accounted for less than 1% of both the small whale sightings and the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 1.4, the smallest for all odontocetes and also for all small whale species. The mode was 1, with a range of from 1 to 3.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. Four of the five beluga whale sightings were found in waters just off the southern coast of Long Island. These sightings were found during the months of March, April, and June, and a single individual was reported on each occasion. During July 1979, 3 individuals were reported from the OCS edge, east of Cape May, New Jersey. The reliability of this sighting, however, was "unsure" and so a hypothetical distribution of beluga whales as far south as southern New Jersey remains questionable. The locations of these sightings are shown in Figure 33.

While beluga whales are more commonly found in the Gulf of St.Lawrence area and northward to the Arctic Circle (Leatherwood et al.,1976), Reeves and Katona (1980) have compiled records showing the not uncommon extralimital straying of usually single individuals from their normal range southward a far as Cape Cod, Long Island, and New Jersey. In their view, beluga whales should be considered a small but normal component of our boreal marine mammal fauna.

Feeding. Feeding was not observed in this species.

Calves and Juveniles. No calves or juveniles of *D. leucas* were reported.

Areas. A single "unsure" sighting of 3 individuals on 5 July 1979 was found within Lease Sale Area 40, 49, and 59. No sightings were found within Lease Sale Area 42 or within Proposed Lease Sale Area 52.

POPULATION ESTIMATES AND STATUS

Population Estimates. Population estimates of *D. leucas* were not possible from the CETAP data.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). Only one sighting with depth information was available. The water depth for this sighting was 91m. Other sightings were nearshore, and in shallow waters of bays and sounds.

BEHAVIOR

Associations. *Delphinapterus leucas* was not reported in proximity to another species of cetacean during the three year CETAP survey effort.

Migration and Movement. Too few sightings were reported to suggest any regular migration patterns. The data do suggest that individuals seen within the study area are strays from the population center to the north. Whether any of these individuals successfully make the return journey is not known.

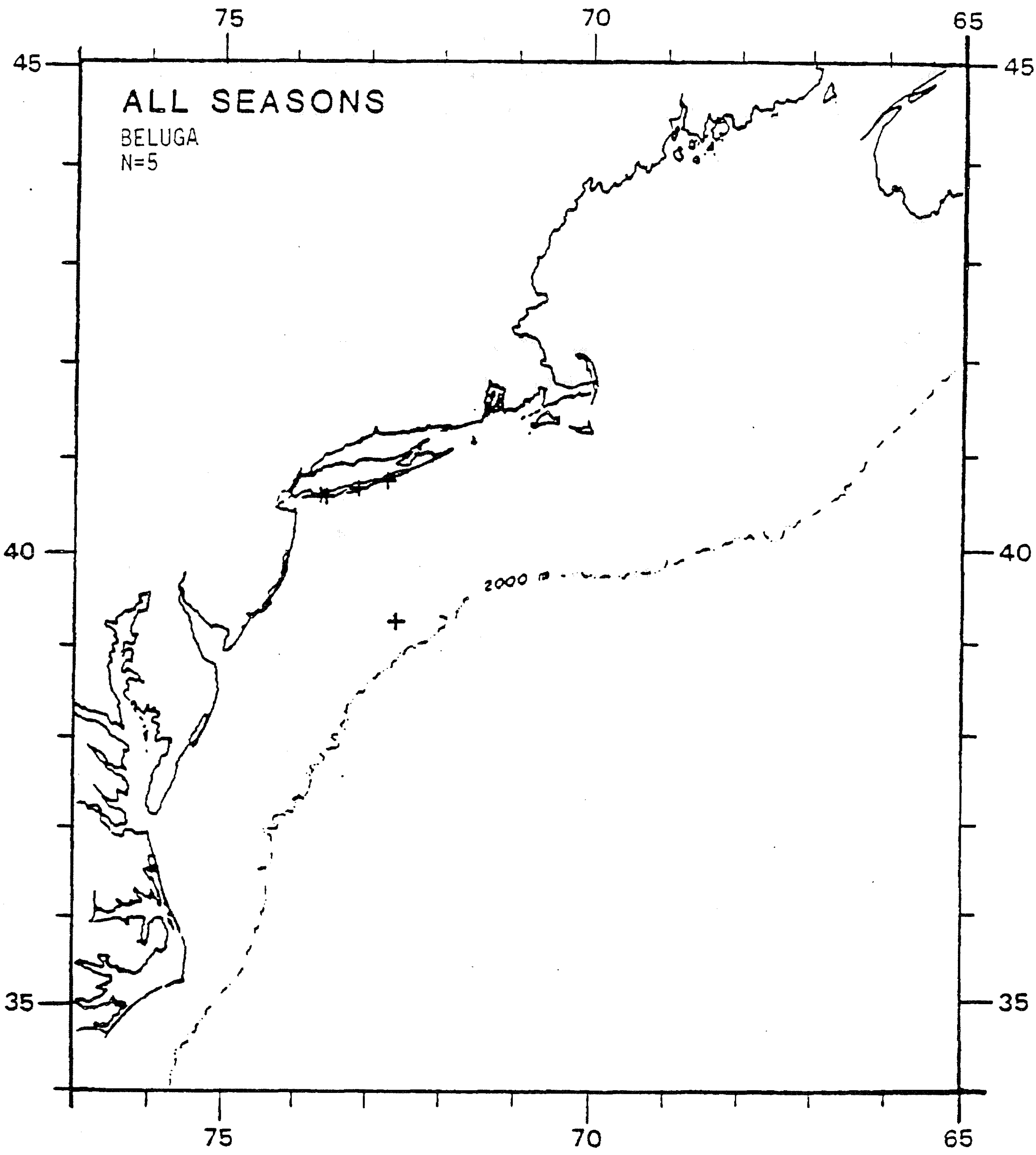

Figure 33. All sightings of the beluga whale, Delphinapterus leucus for the 39 month period -- 1 November 1978 through 28 January 1982.

Phocoena phocoena - Harbor porpoise

INTRODUCTION

1981 Data. The 1981 data were consistent with the data from CETAP studies in 1979 and 1980. A sighting on 18 Feburary 1981 extended westward by about 60 n.mi. the known winter range of the species. The sections below describe the cumulative results.

Number of Sightings. *P. phocoena* was the second most commonly sighted small whale species. The 778 sightings of 2246 individuals accounted for 18% of the small whale sightings and 17% of the odontocete sightings during the 3 year survey period.

Individuals per Sighting. The average number of individuals per sighting was 2.9, the third smallest for odontocete and also small whales. The mode was 1, with a range from 1 to 75.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. *Phocoena phocoena* is the most common of the three odontocete species which occupy the continental shelf in waters shoreward of the 100 m depth contour. The distribution is predominantly north of 40°N, in New England waters, and has a strong seasonal component (Figures 34a-d). Spring and summer appear to contain similar abundance levels, but the distribution shifts markedly between the two seasons. In spring, there are numerous sightings east and southeast of Cape Cod, with the highest abundance levels in the northern Gulf of Maine and at the Bay of Fundy entrance. In summer, the abundance levels in the northern Gulf of Maine remain, but sightings through the western Gulf of Maine and around Cape Cod are almost completely absent. In fall and winter, the overall abundance of the species in the study area is much reduced, but scattered sightings continue to be found around Cape Cod and through the Gulf of Maine.

The CETAP data from southern New England waters west to about 73°30'W longitude extend the live-sightings of the harbor porpoise over the OCS south and west of that previously described (Katona et al., 1978). Reports summarized by Katona et al. (1978) and Prescott and Fiorelli (1980) include strandings as far south as Delaware and recent sightings in the Chesapeake Bay. Therefore, the range of the species either regularly or periodically extends further than the CETAP data indicate.

To the north, data summarized by Prescott and Fiorelli (1980) indicate that the Bay of Fundy and its approaches support a large number of *Phocoena*, perhaps as much as 80 percent of the total summer population south of the Gulf of St. Lawrence.

Feeding. Sightings of surface feeding harbor porpoises were quite infrequent, only 0.5% of the total general sightings. Of these few sightings (4), one was in the Great South Channel, and three were in the northern Gulf of Maine, primarily inshore (Fig. 34e). These two general areas were regions of heavy concentrations of general harbor porpoise sightings.

Harbor porpoise are primarily piscivorous, often feeding near the bottom. Their main diet items are cod, mackerel, herring, and various benthic invertebrates (Smith and Gaskin, 1974). Their primarily sub-surface fish diet and their inconspicuous nature are reasons why surface feeding was so rarely sighted in the current study. Smith and Gaskin (1974) reported that harbor porpoise consume approximately 10% of their body weight per day. Therefore, they are likely feeding throughout the range of general sightings, and not just in the locations observed.

No surface feeding sightings were made in the Lease Areas, but numerous general sightings were made in Area 42 and Proposed Area 52. In addition, there were significant numbers of general sightings of harbor porpoise to the northwest of Area 42 and Proposed Area 52. It is likely that harbor porpoises feed within these two Lease Areas.

Calves and Juveniles. During the three year survey period, 52 sightings of calves and juveniles were reported (Figure 34f). Calves were sighted from Nantucket Shoals to the Bay of Fundy. The distribution of adults extended slightly farther south to waters east of New Jersey. Calf sightings during the summer (31 sightings) were farther north, greater in frequency, and more concentrated than the sightings reported during the spring (20 sightings). Calves were seen only once during the fall, and not at all during the winter.

Prescott and Fiorelli (1980) reported that the frequency of births of harbor porpoise calves reaches a peak during June and July. This might explain the increase in calf sightings during summer months in this survey. Sightings of calves as far north as the Bay of Fundy were not surprising since calves have been previously reported from those waters (Prescott and Fiorelli, 1980). Gaskin found that *Phocoena* cow/calf pairs have a greater preference for protected waters than non-calf groups (as cited in Kraus and Prescott, 1981). This trend was not apparent in the results of the CETAP survey (as cited in Kraus and Prescott, 1981).

Although calves were found mostly in groups of two animals (mother/calf pairs), a few groups as large as 15-25 animals included calves.

No calves were found within Lease Sale Areas 40, 42, 49, or 59. During the spring, one sighting was found within Proposed Lease Sale Area 52.

Areas. To date, no harbor porpoise sightings have been reported from Mid-Atlantic Lease Sale Areas 40, 49, and 59. In the North Atlantic, *Phocoena* is common and widespread in Lease Sale 42 in the spring, occurs there rarely in summer, and apparently not at all in fall and winter. In the portion of Proposed Lease Sale Area 52 lying outside of 42, *Phocoena* occurs at moderate levels on a scattered basis in spring, occurs there rarely in summer, and apparently not at all in fall and winter.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 22 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 34g. The peak average abundance estimate for harbor porpoise in the study area was 3541 (+/- 1486) during spring. The maximum point estimate of abundance for this species was 4747 (+/- 4425) for sampling block B during June 1979. After post-stratification of the 1979 data, the maximum point abundance estimate was 4202 (+/- 3979) in sampling block B, stratum z, in June 1979.

ENVIRONMENTAL DATA

Water Temperature (°C). The average water temperature for *P. phocoena* sightings was 12.0°C, the coolest for all small whales, and also all odontocete species. The mode was 10.0 with a range from 3.0 to 20.0'C. Ninety percent of these sightings were made in cold to moderately warm water (6.5 to 17.3°C). These data are consistent with the northerly and inshore distribution of the species.

Depth (m). The average depth was 124m, the second shallowest for all odontocete and also all small whale species. The mode was 18, with a range from 6 to 2743m. Ninety percent of all sightings were made over a relatively shallow depth range (18 to 224m). This corresponds well with the distribution of harbor porpoise sightings along the continental shelf and in coastal waters.

BEHAVIOR

Associations. The harbor porpoise was observed with one or more of 8 cetacean species in 3% of sightings of P.phocoena. Similar to L.acutus and unlike other small odontocete species, associations involving P.phocoena occurred more frequently with baleen whales than with toothed whales (refer to Table 30). Three species of baleen whales, B.acutorostrata, B.physalus, and M.novaeangliae (arranged in decreasing order of frequency) accounted for 70% of all harbor porpoise associations. By contrast, associations involving L. acutus represented on 17.5% of total Phocoena associations. Single occurrences with E.glacialis, G.griseus, L.albirostris, and Globicephala spp. were also reported. Multispecies sightings were more rare for P.phocoena (on a percentage basis) than for any other cetacean species found in multispecies aggregations.

Migration and Movement. Reduced levels of Phocoena in fall and winter suggest a seasonal migration for the species. Speculation that at least a portion of the population spends winter south of Cape Cod is supported by strandings of young harbor porpoise during February and March in Virginia and North Carolina (Katona et al., 1978). There is also speculation that offshore areas may be involved (Prescott and Firoelli, 1980).

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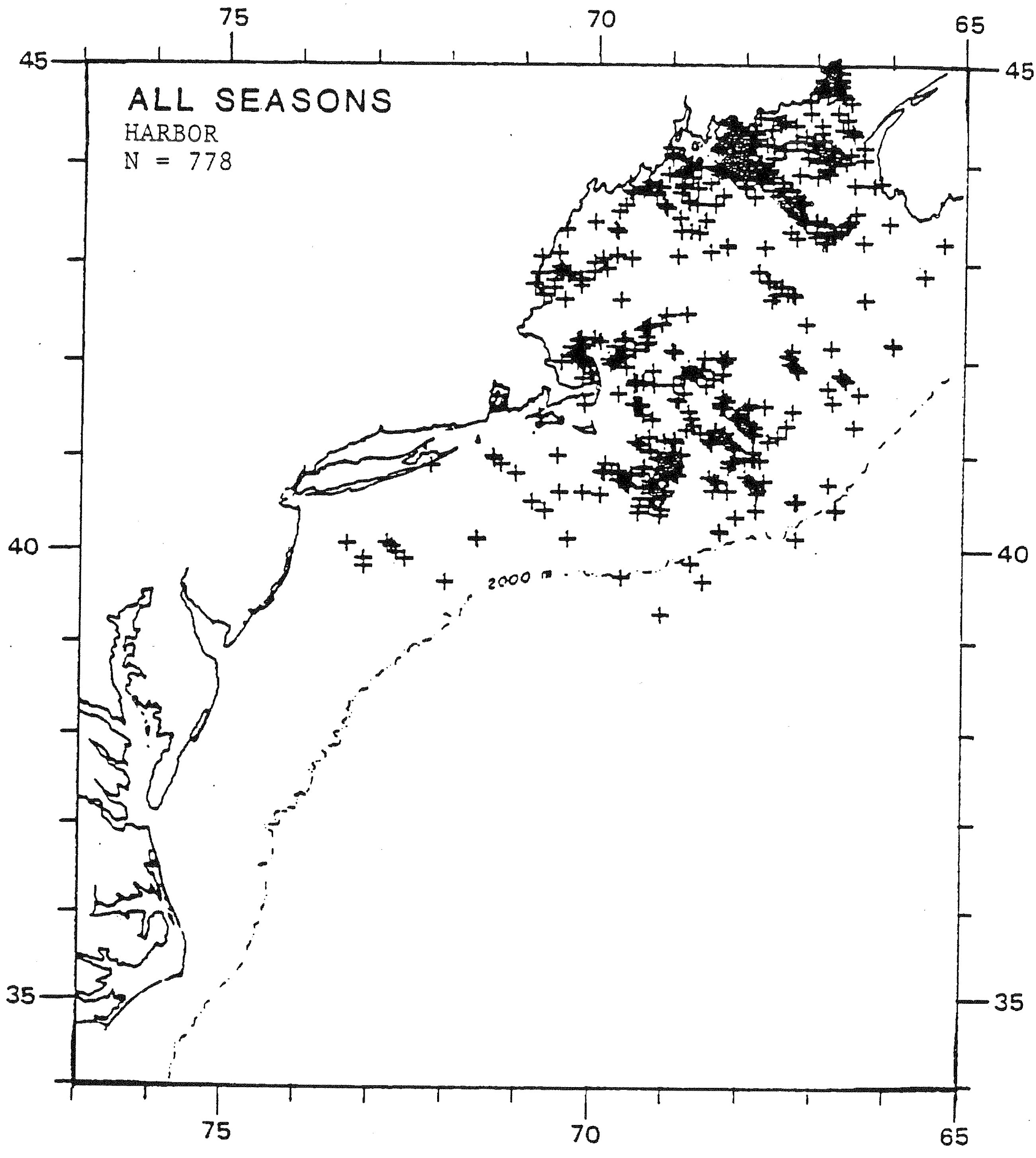

Figure 34a. All sightings of the harbor porpoise, *Phocoena phocoena*, for the 39 month period -- 1 November 1978 through 28 January 1982.

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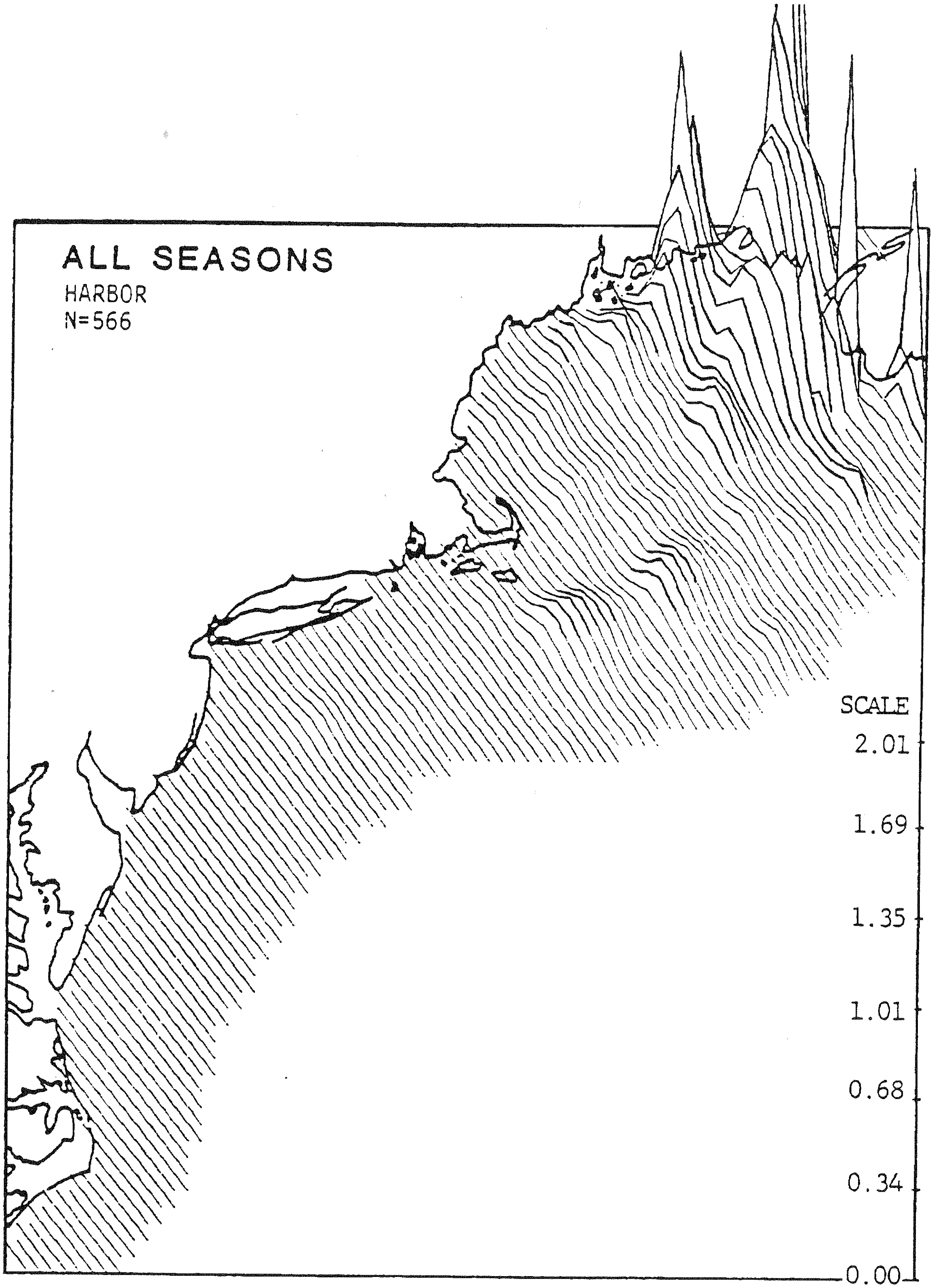

Figure 34b. The relative abundance of P. phocoena for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

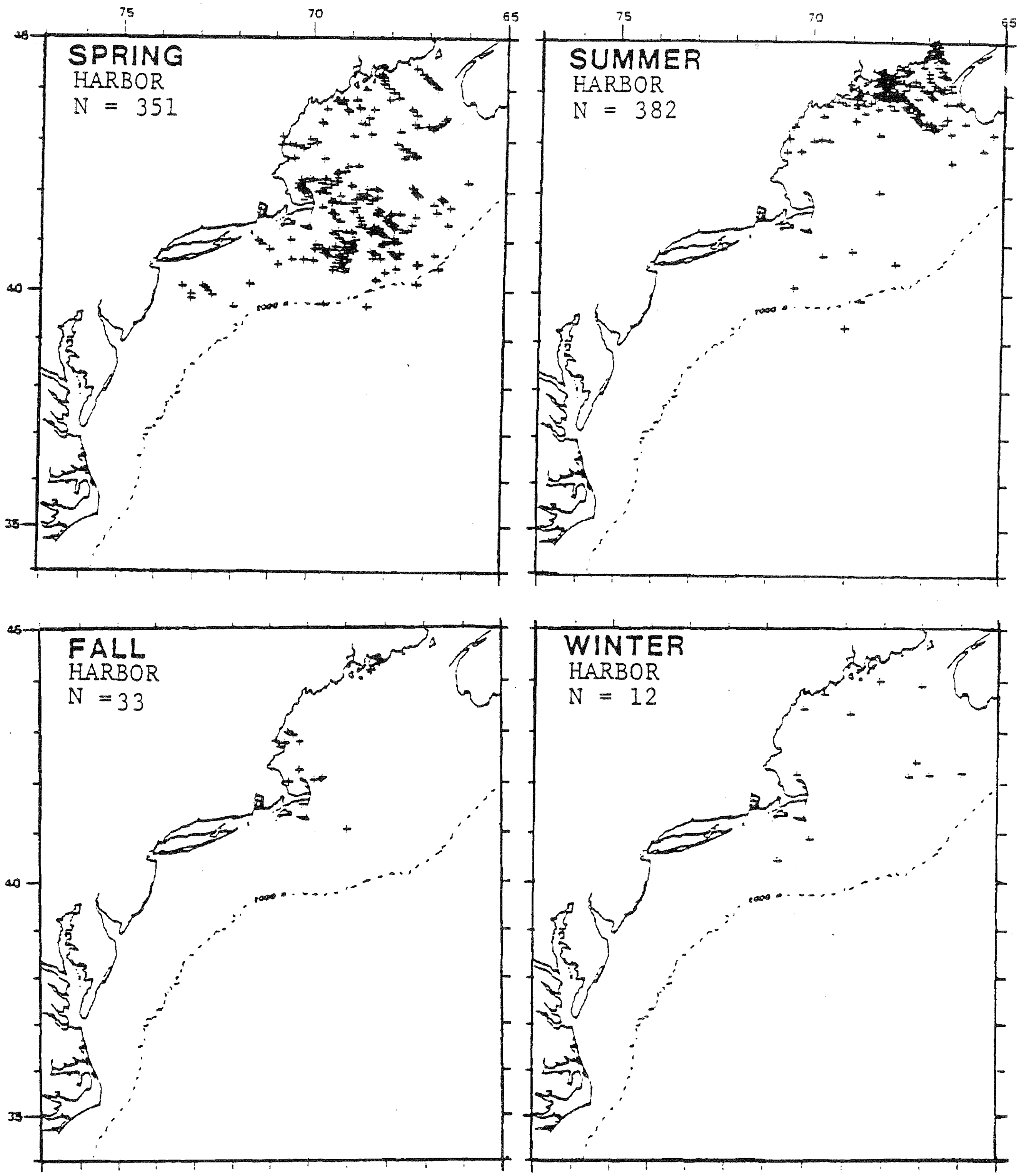

Figure 34c. The sighting distribution of P. phocoena by season.

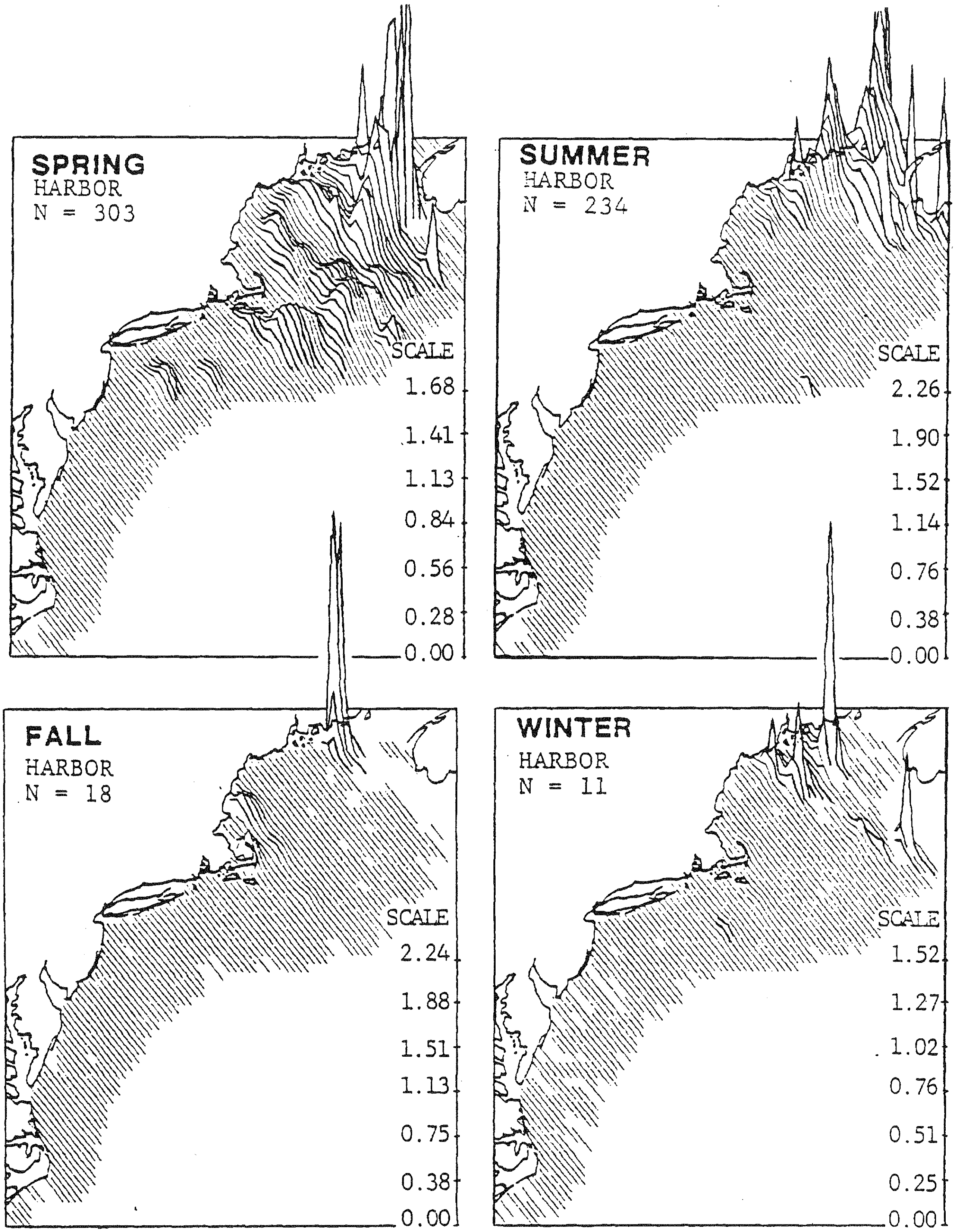

Figure 34d. The relative abundance of P. phocoena by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

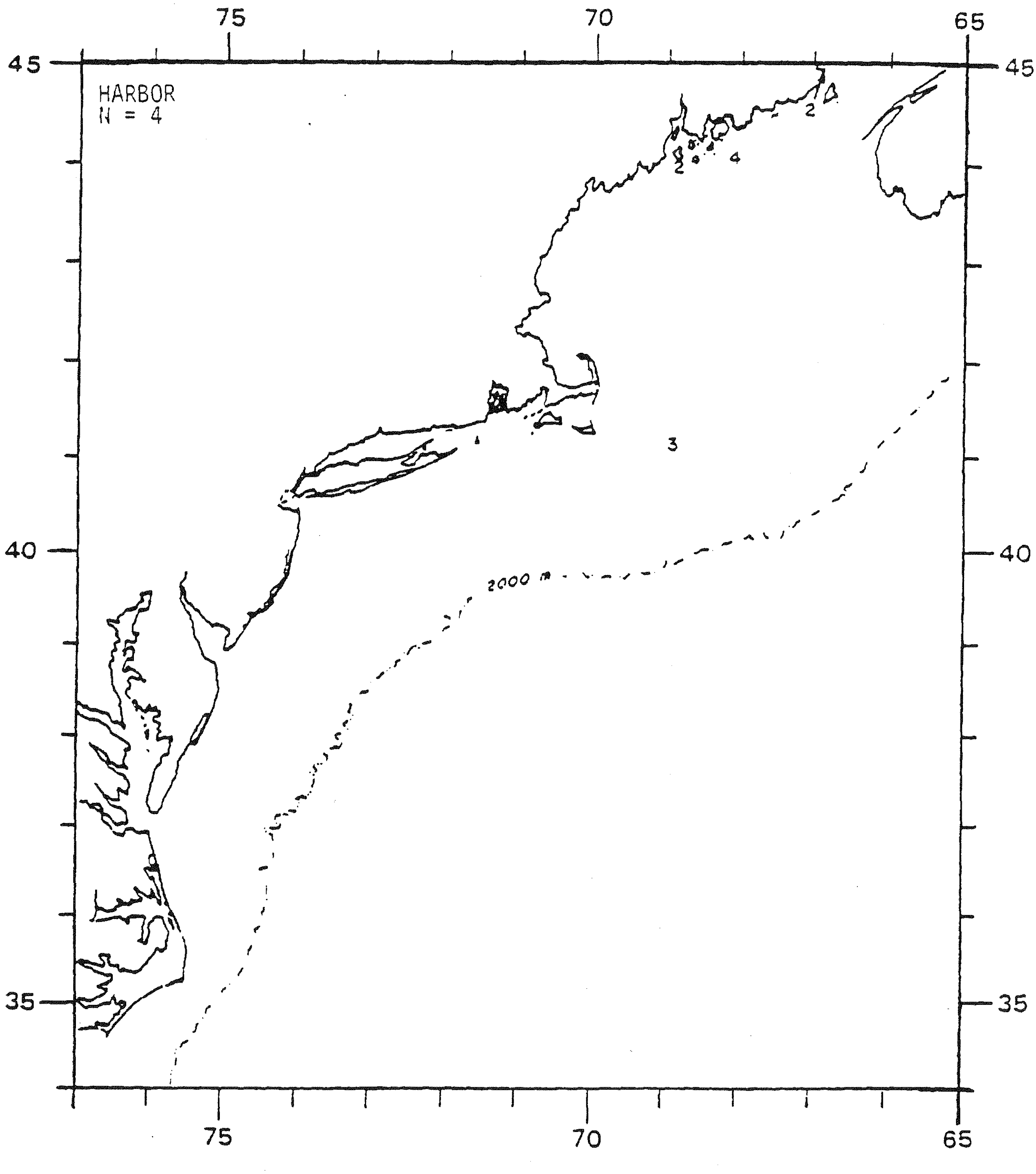

Figure 34e. Locations of sightings of feeding or apparent feeding of P. phocoena. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

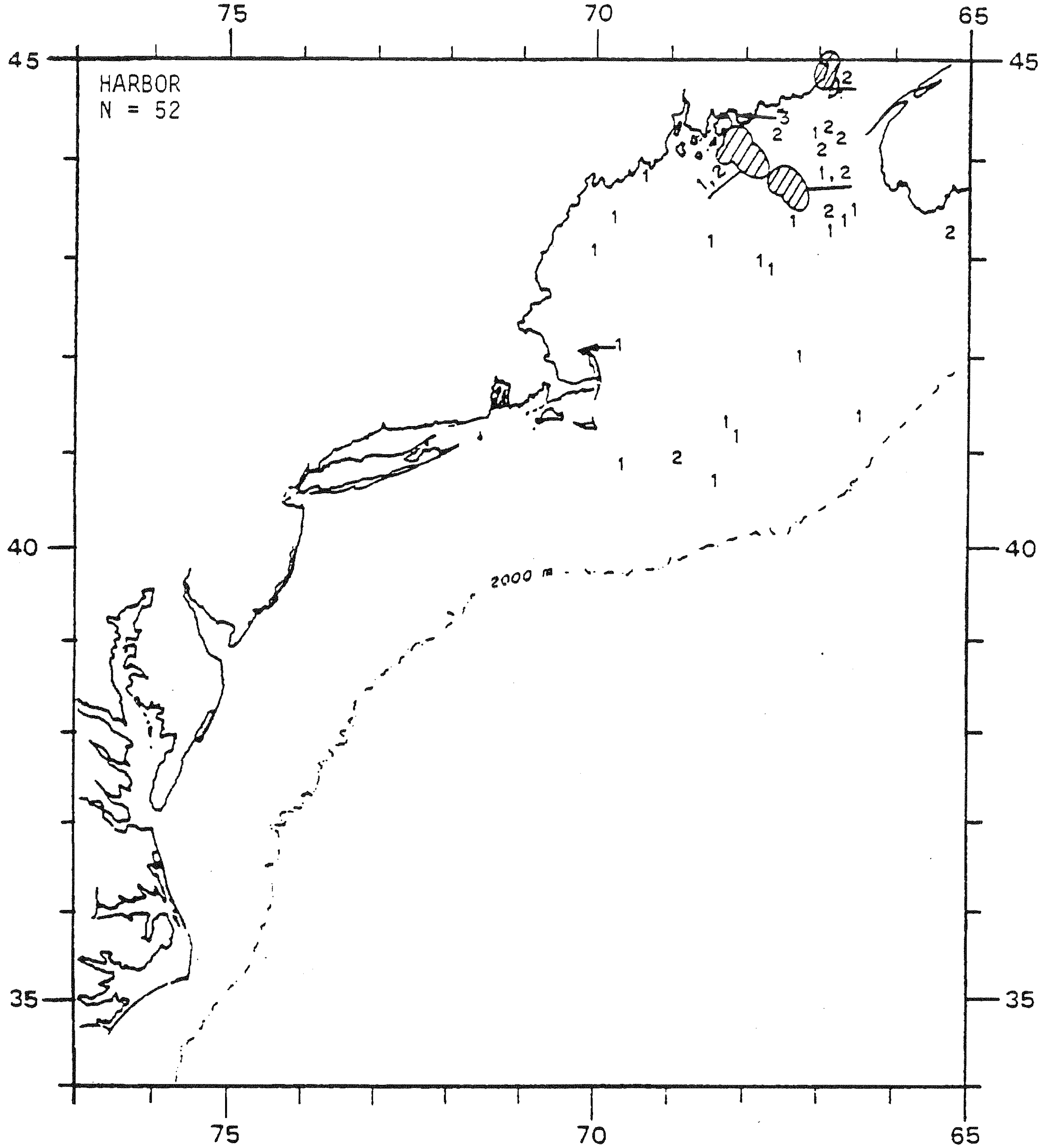

Figure 34f. Sightings of calves or juveniles of P. phocoena. Single and widely separated observations are denoted by a number indicating the season in which the sighting ocurred (1 = spring, 2 = summer, 3 = fall, 4 = winter), plotted at the sighting location. Where several observations are concentrated in an area, the area has been enclosed by a lined region and the seasons of the included observations are shown on the adjoining line.

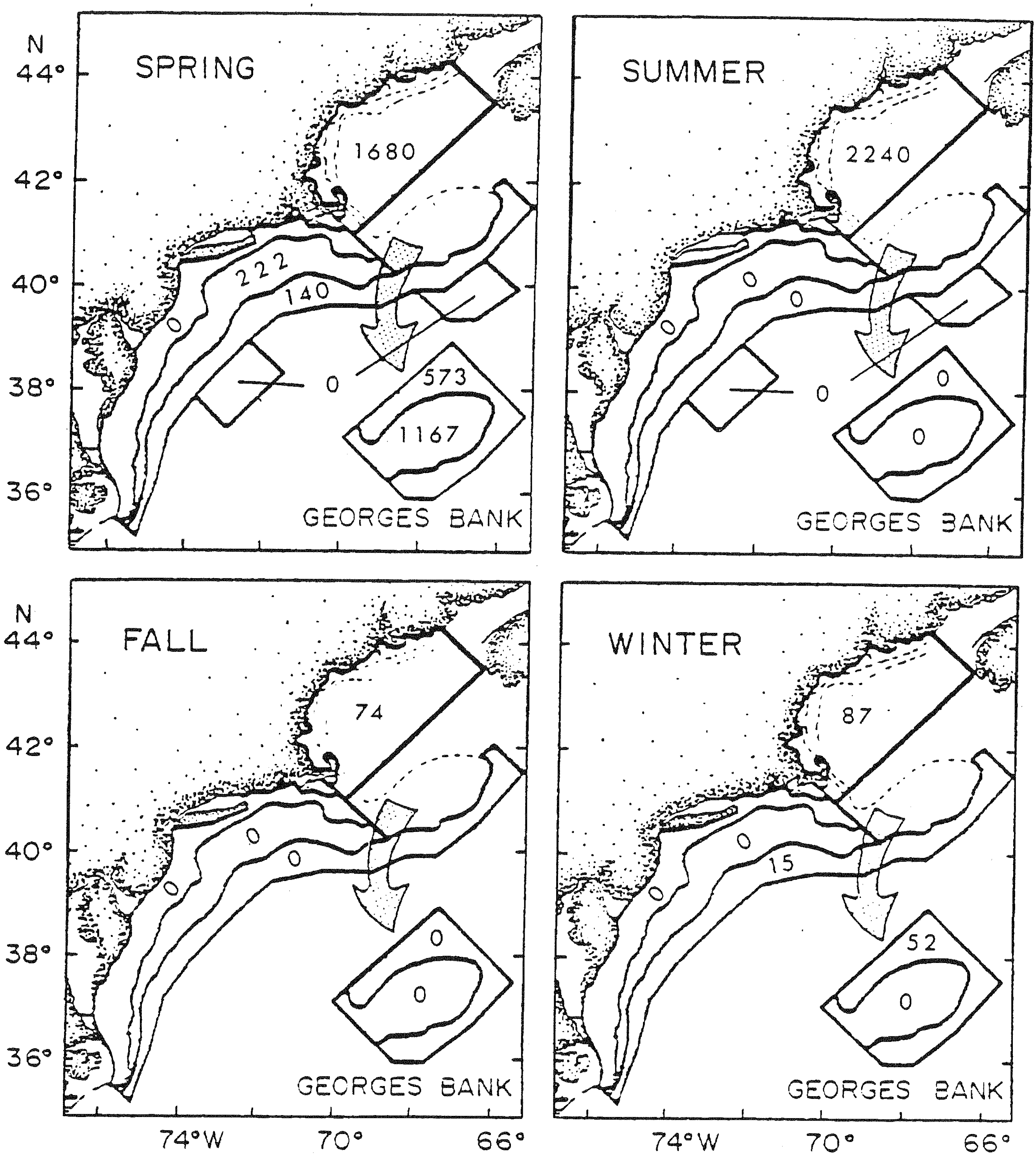

Figure 34g. Estimates of the number of individuals of P. phocoena by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 22. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Phocoena phocoena*.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	2.33E-02	3.11E-02	1.03E-03	1.20E-03
	1.74E-03	4.53E-03	1.70E-05	2.77E-05
	1680	2240	74	87
	± 1271	± 2208	± 165	± 157
GEORGES BANK	2.64E-02	0.00E+00	0.00E+00	5.43E-04
	1.98E-03	0.00E+00	0.00E+00	3.92E-06
	1821	0	0	37
	± 1018	± 0	± 0	± 58
<50 FATHOMS	3.61E-02	0.00E+00	0.00E+00	0.00E+00
	2.82E-03	0.00E+00	0.00E+00	0.00E+00
	1167	0	0	0
	± 883	± 0	± 0	± 0
>50 FATHOMS	1.56E-02	0.00E+00	0.00E+00	1.41E-03
	1.06E-03	0.00E+00	0.00E+00	1.02E-05
	573	0	0	52
	± 593	± 0	± 0	± 79
LEASE SALE 52	6.96E-03	0.00E+00	0.00E+00	0.00E+00
	1.96E-04	0.00E+00	0.00E+00	0.00E+00
	194	0	0	0
	± 201	± 0	± 0	± 0
MID-ATLANTIC	1.86E-03	0.00E+00	0.00E+00	0.00E+00
	8.92E-05	0.00E+00	0.00E+00	0.00E+00
	255	0	0	0
	± 313	± 0	± 0	± 0
NEAR SHORE	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0	0	0	0
	± 0	± 0	± 0	± 0
MID-SHELF	4.24E-03	0.00E+00	0.00E+00	0.00E+00
	2.04E-04	0.00E+00	0.00E+00	0.00E+00
	222	0	0	0
	± 323	± 0	± 0	± 0
NEW YORK BIGHT	1.62E-03	0.00E+00	0.00E+00	0.00E+00
	3.77E-05	0.00E+00	0.00E+00	0.00E+00
	100	0	0	0
	± 157	± 0	± 0	± 0
SHELF EDGE	2.26E-03	0.00E+00	0.00E+00	2.46E-04
	4.56E-05	0.00E+00	0.00E+00	1.62E-06
	140	0	0	15
	± 163	± 0	± 0	± 34
CONTINENTAL SLOPE	0.00E+00	0.00E+00	.	.
	0.00E+00	0.00E+00	.	.
	0	0	.	.
	± 0	± 0	± .	± .
STUDY AREA OCS*	3541	1767	62	108
	± 1486	± 1643	± 128	± 138

*Study area OCS does not include the slope water regions.

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Dermochelys coriacea - Leatherback turtle - Endangered Species

INTRODUCTION

1981 Data. The 1981 data were generally consistent with observations from both 1979 and 1980. However, in 1981, an unusually large incidental catch of leatherbacks was reported in pound nets off the Rhode Island shore.

Number of Sightings. During the three year period, *D. coriacea* was the second most commonly observed sea turtle with 122 sightings totalling 142 individuals reported from the study area.

Individuals per Sighting. The average number of individuals per sighting was 1.2, with a mode of 1 and a range from 1 to 5.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. Leatherbacks were observed throughout the study area (Figures 35a-d). While they regularly visit the Gulf of Maine, most leatherbacks were sighted south of New England. Although often termed an "oceanic species", *D.coriacea* was more frequently observed in the shallower portions of the OCS. Leatherback sightings peak during the summer, evidencing a strong temporal aspect to their distribution.

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Nesting areas for this species are located primarily in the subtropical and tropical regions of Mexico and northern South America, although one female leatherback found dead on the shore of New Jersey was known to have nested in the U.S. Virgin Islands only months before.

Leatherback turtles were observed in Proposed Lease Sale Area 52, and likewise on the boundary of Area 42 in both summer and fall, and along the western margin of Areas 40, 49, and 59 during spring, summer, and fall.

Feeding. No sightings of feeding leatherbacks were reported during the CETAP field surveys.

Hatchlings and Juveniles. No observations of hatchling or known juvenile leatherback turtles were recorded during the 3 year field surveys.

Areas. Based on CETAP data, the near-shore and mid-shelf regions of the Mid-Atlantic, principally areas of the New York Bight, contain the majority of sightings of leatherback turtles. Since the majority of these sightings occur during the summer, it is assumed that these turtles are following the concentrations of jellyfish that form the major part of their diet as they move into these areas during the warmer summer months.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 23 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 35e. The peak average abundance estimate of leatherback turtles in the Study Area was 361 (+/- 181) and occurred during summer. The maximum point estimate of abundance of this species was 517 (+/- 468) in sampling block F during September 1979. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. These estimates are undoubtedly conservative due to animal diving behavior and other factors.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 57 sightings of this species. The average surface water temperature for sightings of leatherback turtles was was 21.1°C with a mode of 22, and a range from 11.3 to 27.2°C.

Depth (m). Water depths at leatherback sightings averaged 243m, with a mode of 18, and a range from 11 to 4151m. While the range of water depths at sightings varied widely, indicating that leatherback turtles frequent many regions of the OCS, most sightings occurred in water depths of less than 60m.

BEHAVIOR

Associations. Not done for turtle species.

Migration and Movement. Leatherback turtles observed within the study area are migrants from more tropical waters. While specific routes remain undetermined, previous data have suggested that, during their northward migration, some individuals may utilize the Gulf Stream before moving inshore. Support for this comes from the fact that individual leatherback turtles have occasionally first appeared in the Gulf of Maine, rather than as an orderly progression of sightings moving from the southern portions of the study area to the northern summertime range. However, since attempts to define migratory routes by using resightings of tagged individuals have not succeeded, other methods, including radio tags and satellite tracking, will have to be employed.

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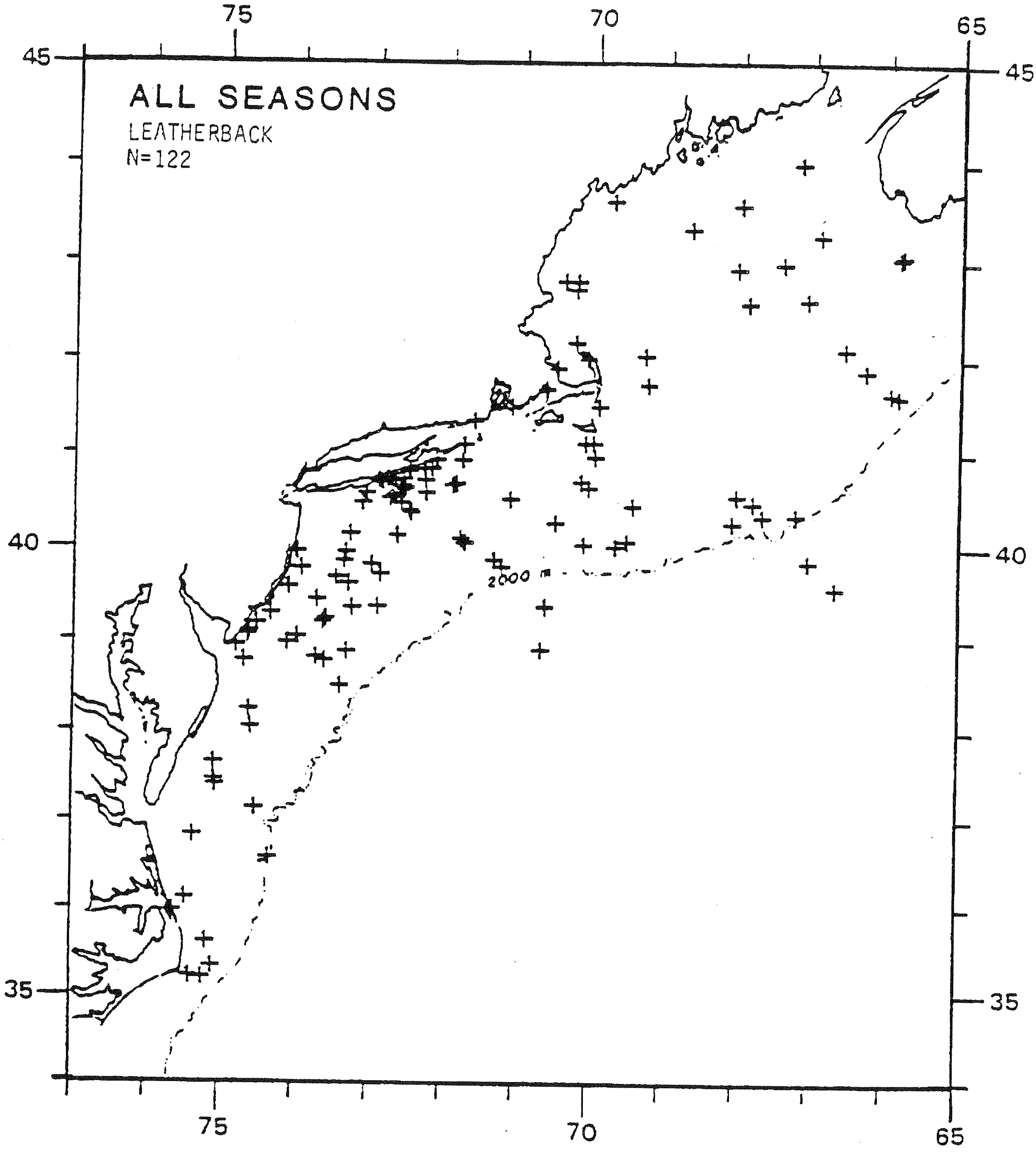

Figure 35a. All sightings of the leatherback turtle, Dermochelys coriacea, for the 39 month period -- 1 November 1978 through 28 January 1982.

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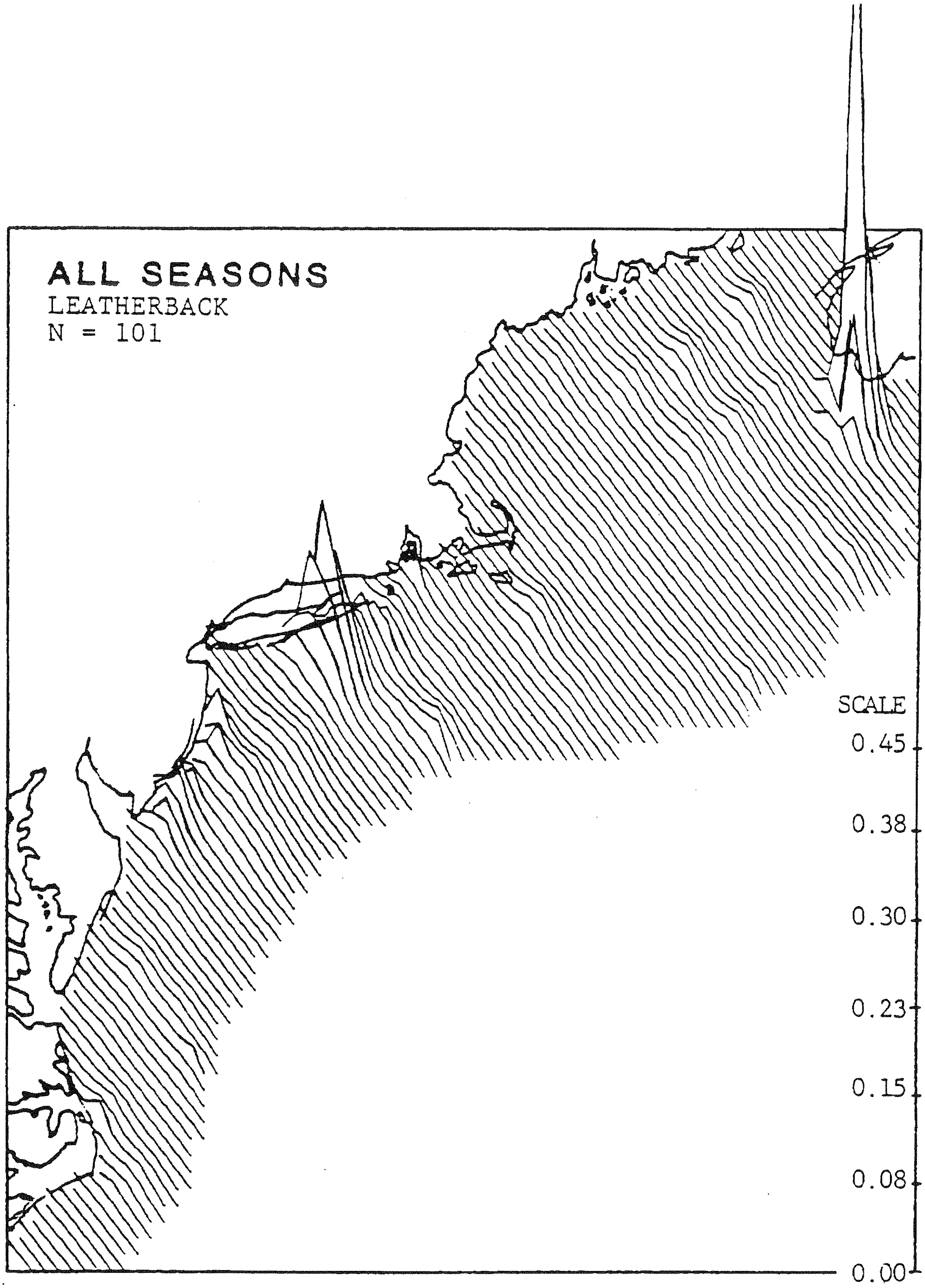

Figure 35b. The relative abundance of D. coriacea for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

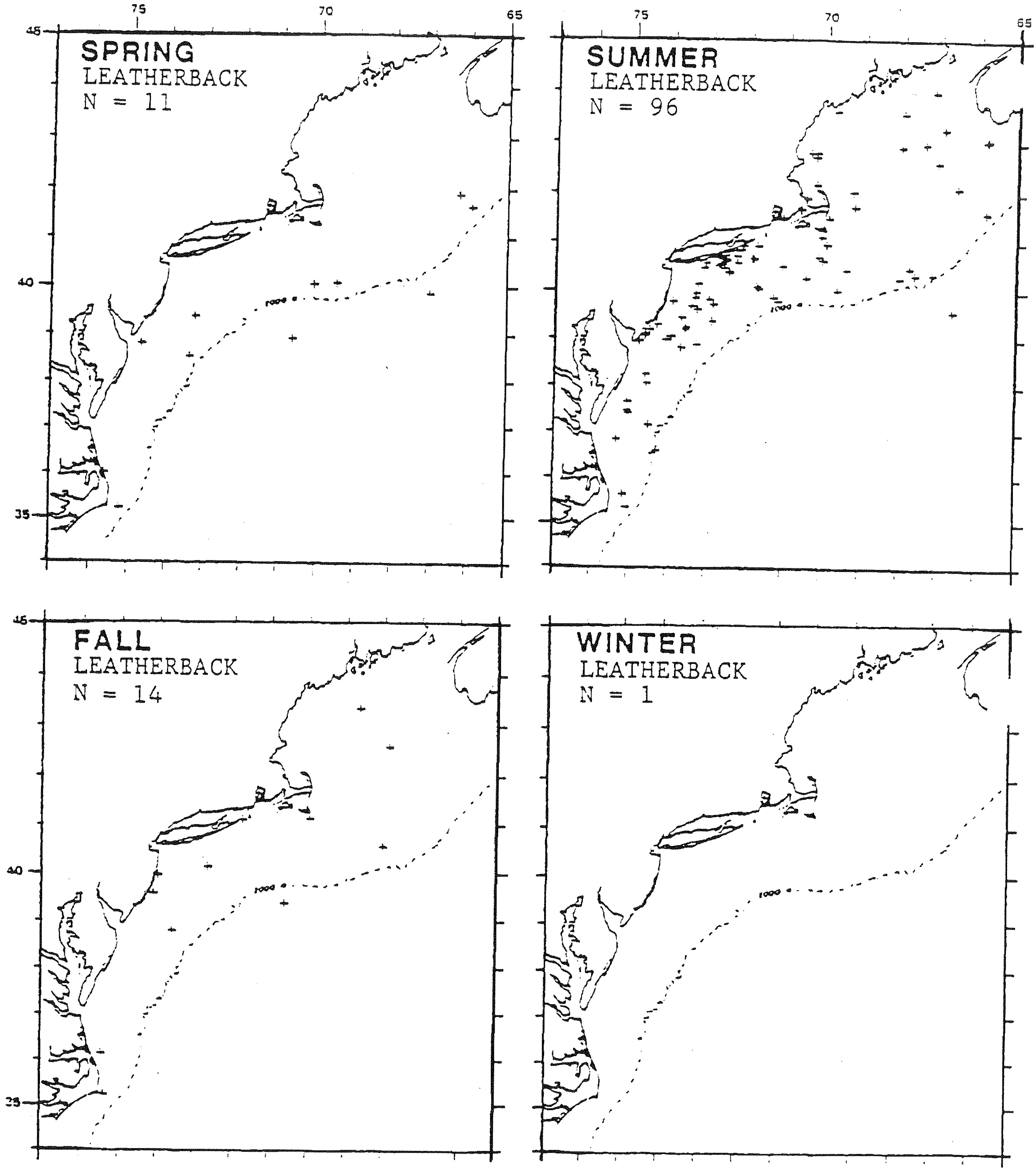

Figure 35c. The sighting distribution of *D. coriacea* by season.

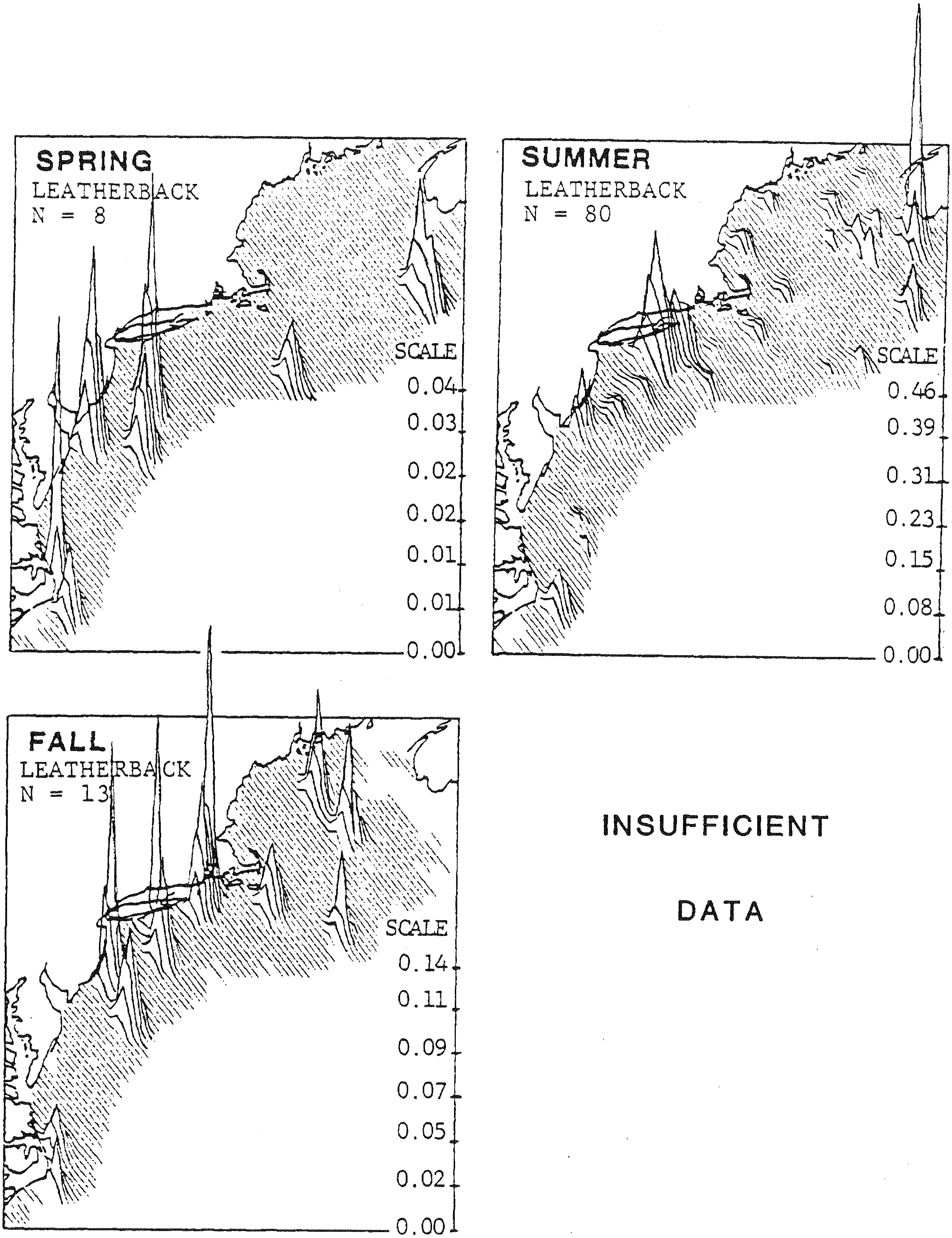

Figure 35d. The relative abundance of D. coriacea by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

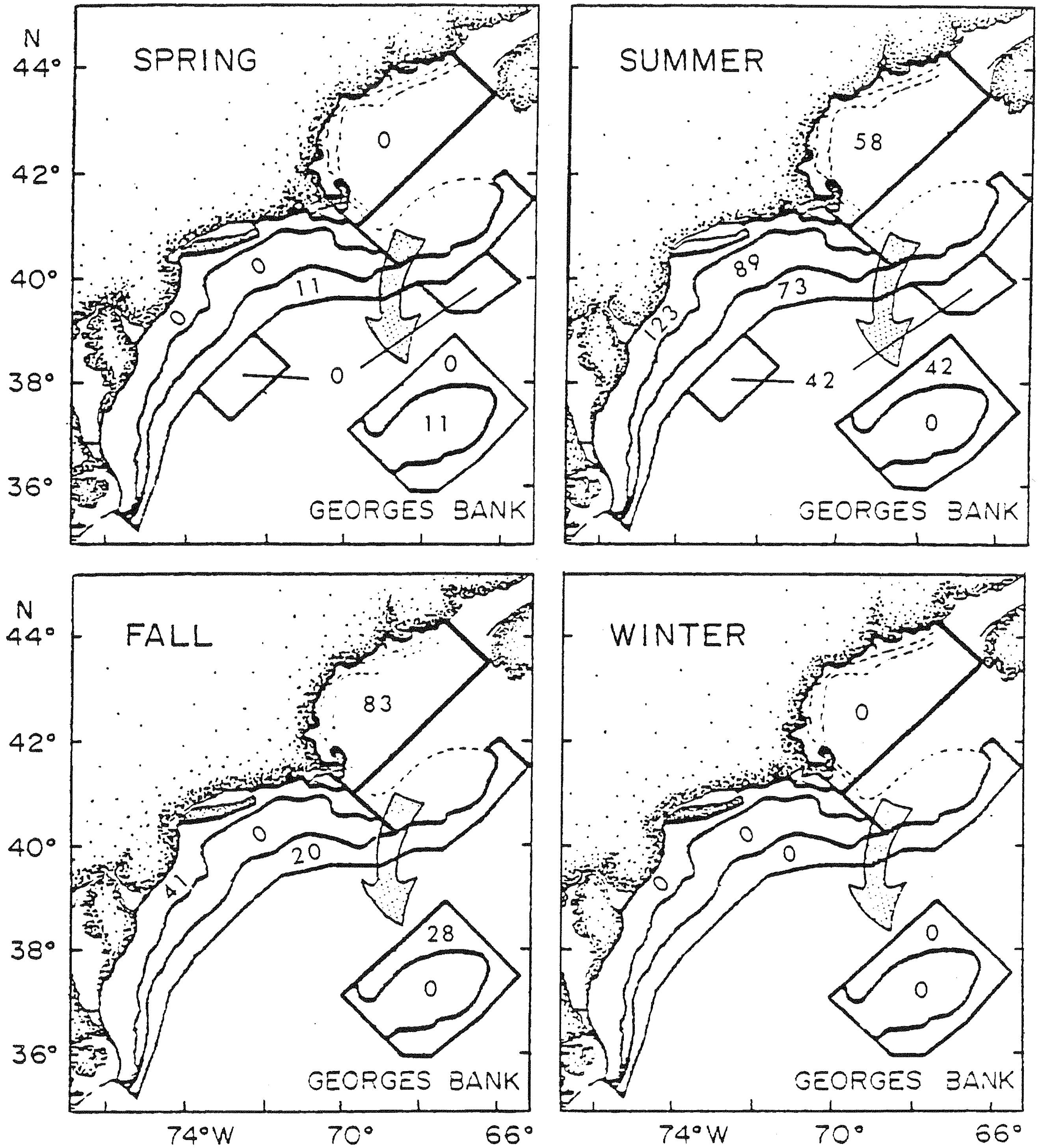

Figure 35e. Estimates of the number of individuals of D. coriacea by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 23. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for <u>Dermochelys coriacea</u>.

REGION	SPRING	SUMMER	FALL	WINTER
GULF OF MAINE	0.00E+00	8.07E-04	1.15E-03	0.00E+00
	0.00E+00	2.23E-06	2.52E-06	0.00E+00
	0	58	83	0
	± 0	± 49	± 63	± 0
GEORGES BANK	1.75E-04	5.34E-04	4.37E-04	0.00E+00
	1.05E-06	2.40E-06	1.56E-06	0.00E+00
	12	37	30	0
	± 23	± 41	± 66	± 0
<50 FATHOMS	3.33E-04	0.00E+00	0.00E+00	0.00E+00
	2.00E-06	0.00E+00	0.00E+00	0.00E+00
	11	0	0	0
	± 24	± 0	± 0	± 0
>50 FATHOMS	0.00E+00	1.15E-03	7.71E-04	0.00E+00
	0.00E+00	5.17E-06	2.74E-06	0.00E+00
	0	42	28	0
	± 0	± 46	± 75	± 0
LEASE SALE 52	1.70E-04	4.53E-04	5.88E-04	0.00E+00
	5.75E-07	2.75E-06	2.09E-06	0.00E+00
	5	13	16	0
	± 11	± 28	± 42	± 0
MID-ATLANTIC	6.78E-05	1.88E-03	3.28E-04	0.00E+00
	2.24E-07	1.93E-05	1.29E-06	0.00E+00
	9	258	45	0
	± 16	± 164	± 47	± 0
NEAR SHORE	0.00E+00	3.01E-03	9.98E-04	0.00E+00
	0.00E+00	2.56E-05	3.93E-06	0.00E+00
	0	123	41	0
	± 0	± 106	± 45	± 0
MID-SHELF	0.00E+00	1.71E-03	0.00E+00	0.00E+00
	0.00E+00	1.91E-05	0.00E+00	0.00E+00
	0	89	0	0
	± 0	± 118	± 0	± 0
NEW YORK BIGHT	6.11E-05	3.45E-03	6.62E-04	0.00E+00
	1.96E-07	3.97E-05	2.60E-06	0.00E+00
	4	214	41	0
	± 11	± 173	± 51	± 0
SHELF EDGE	1.72E-04	1.17E-03	3.25E-04	0.00E+00
	5.69E-07	1.21E-05	1.16E-06	0.00E+00
	11	73	20	0
	± 18	± 89	± 40	± 0
CONTINENTAL SLOPE	0.00E+00	1.36E-03	.	.
	0.00E+00	4.21E-06	.	.
	0	42	.	.
	± 0	± 569	± .	± .
STUDY AREA OCS*	23	361	145	0
	± 31	± 181	± 84	± 0

*Study area OCS does not include the slope water regions.

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Caretta caretta - Loggerhead turtle - Threatened species

INTRODUCTION

1981 Data. Data from 1981 field surveys increased the number of sightings of Caretta along and seaward of the continental slope. Otherwise, 1981 survey data were consistent with previous efforts.

Number of Sightings. Caretta caretta was the most commonly sighted species of sea turtle in the CETAP study area, representing over 92% of individual turtles observed. During the three year survey effort, loggerhead turtles were sighted of 2594 occasions, for a total of 2926 individuals.

Individuals per Sighting. The average number of individual Caretta observed per sightings was 1.1, with a mode of 1 and a range from 1 to 11.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The loggerhead sea turtle exhibits a wide three-season distribution on the waters of the continental shelf between Cape Hatteras and Cape Cod (Figures 36a-d). Caretta was only rarely observed in the Gulf of Maine, and these few occasions centered around Georges Bank. Loggerhead turtles had a three-season (spring, summer, and fall) distribution in Lease Sale Areas 40, 49, and 59 and in Proposed Lease Sale Area 52. Most sightings were reported for the summer season where *Caretta* was common in Areas 40, 49, and 59 and in the western half of Proposed Lease Sale Area 52. No wintertime sightings were reported within any lease area.

In general, wintertime observations were limited to the southernmost regions of the study area expanding northwards beginning in spring. The northernmost sightings were recorded during late summer, when loggerheads are ubiquitous throughout much of the study area. Their range begins to contract towards southern regions in autumn.

Feeding. Typically, loggerhead sea turtles observed in the study area are not involved in reproductive activities such as nesting or mating. Although rarely observed (Figure 36e), it is believed these turtles utilize the area for feeding. Dead loggerheads washed ashore in Chesapeake Bay and adjacent areas are reported to have had full stomachs and intestines (Lutcavage, pers. comm.). Although known to feed on bottom-dwelling organisms, individual turtles were observed to feed on material attached to flotsam in waters of the OCS. Additionally, juveniles weighing from 60 to 90 pounds entrapped in nets off Rhode Island were judged to be in excellent health. Several of these individuals had large "new growth" areas evidencing the view that the study area is serving as an important feeding area for this species.

Juveniles. During the three year survey period, two sightings of *Caretta* juveniles were reported (Figure 36f). One sighting was found on 26 May 1980 in coastal waters off Cape Hatteras. The second sighting reported on 8 June 1981 was located outside of the continental shelf, east of Maryland.

Neither of these sightings were found within Lease Sale Areas 40, 42, 49, or 59 or within Proposed Lease Sale Area 52.

Areas. Based on CETAP data, waters of the continental shelf south of 41°30'N hold the majority of loggerhead sightings. Within this overall region, the nearshore areas of the New York Bight extending towards the mid-shelf and shelf-edge areas of the southern Mid-Atlantic region harbors the most significant concentration of loggerhead turtles, with the majority occurring during the summer.

POPULATION ESTIMATES AND STATUS

Population Estimates. Seasonal estimates of the average density, variance of the density, abundance, and 95% confidence interval about the mean are presented in Table 24 for the regions defined in the study area. These estimates are based on the combined data for all three years of sampling. The estimates for selected regions are shown graphically in Figure 36g. The peak average abundance of loggerhead turtles in the Study Area was 7702 (+/- 1748) and occurred during the summer. The maximum point estimate of abundance of loggerhead turtles was 4236 (+/- 1117) in sampling block H, stratum x, during June 1980. Post-stratification of the 1979 data did not affect the maximum point abundance estimate. These estimates are undoubtedly conservative due to animal diving behavior and other factors.

ENVIRONMENTAL DATA

Water Temperature (°C). Water temperatures were available for 1708 sightings of this species. The average water temperature at loggerhead sightings was 22.4°C with a mode of 23.0 and a range from 9.0 to 29.5°C. Unlike leatherback sea turtles which inhabit waters with decreasing sea surface temperature as latitude increases, loggerhead turtles appear to prefer water of the same temperature regardless of latitude. Low temperatures limit loggerhead turtle distribution during the colder portions of the year.

Depth (m). Evidencing their widespread distribution, the average water depth recorded at sightings of Caretta caretta was 251m, with a mode of 37, and a range from 0 to 5118.

BEHAVIOR

Associations. Not done for turtles species.

Migration and Movement. Similar to other sea turtle species, loggerheads only temporarily inhabit waters of the study area having migrated from other regions. Caretta nesting locations are common on several southeastern U.S. beaches. Since only limited nesting by this species takes place within the study area - Virginia and North Carolina - and could not account for the numbers of loggerheads observed in the study area, it is assumed that many of the loggerhead turtles in the CETAP study area are from more southerly breeding areas. None of the individuals tagged and released in Rhode Island waters have been reported again, so this hypothesis awaits confirmation. However, the gradual expansion of this species' range during the warmer months, and subsequent reduction during fall and winter, correlates directly with the warming and cooling of the surface waters.

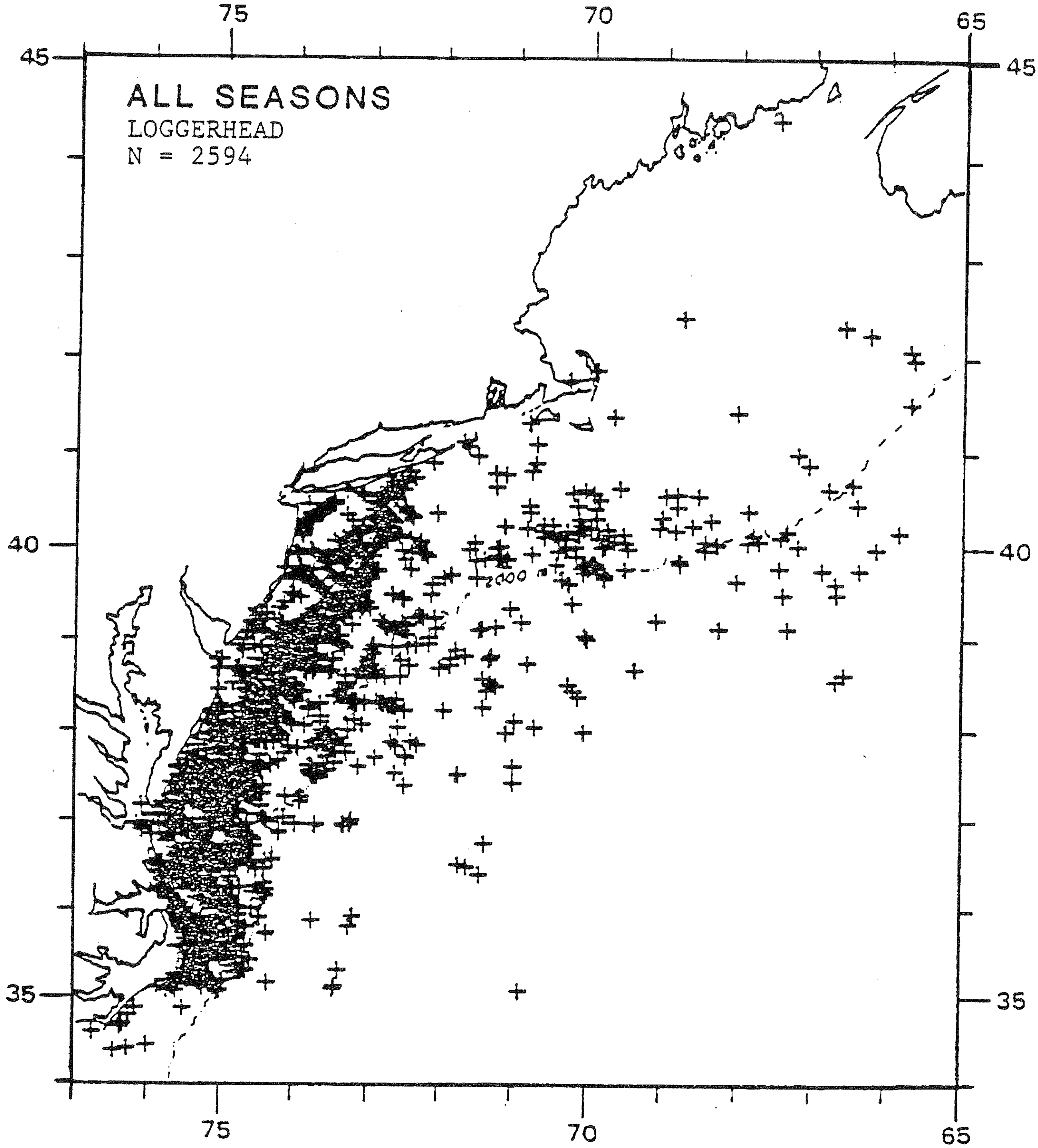

Figure 36a. All sightings of the loggerhead turtle, Caretta caretta for the 39 month period -- 1 November 1978 through 28 January 1982.

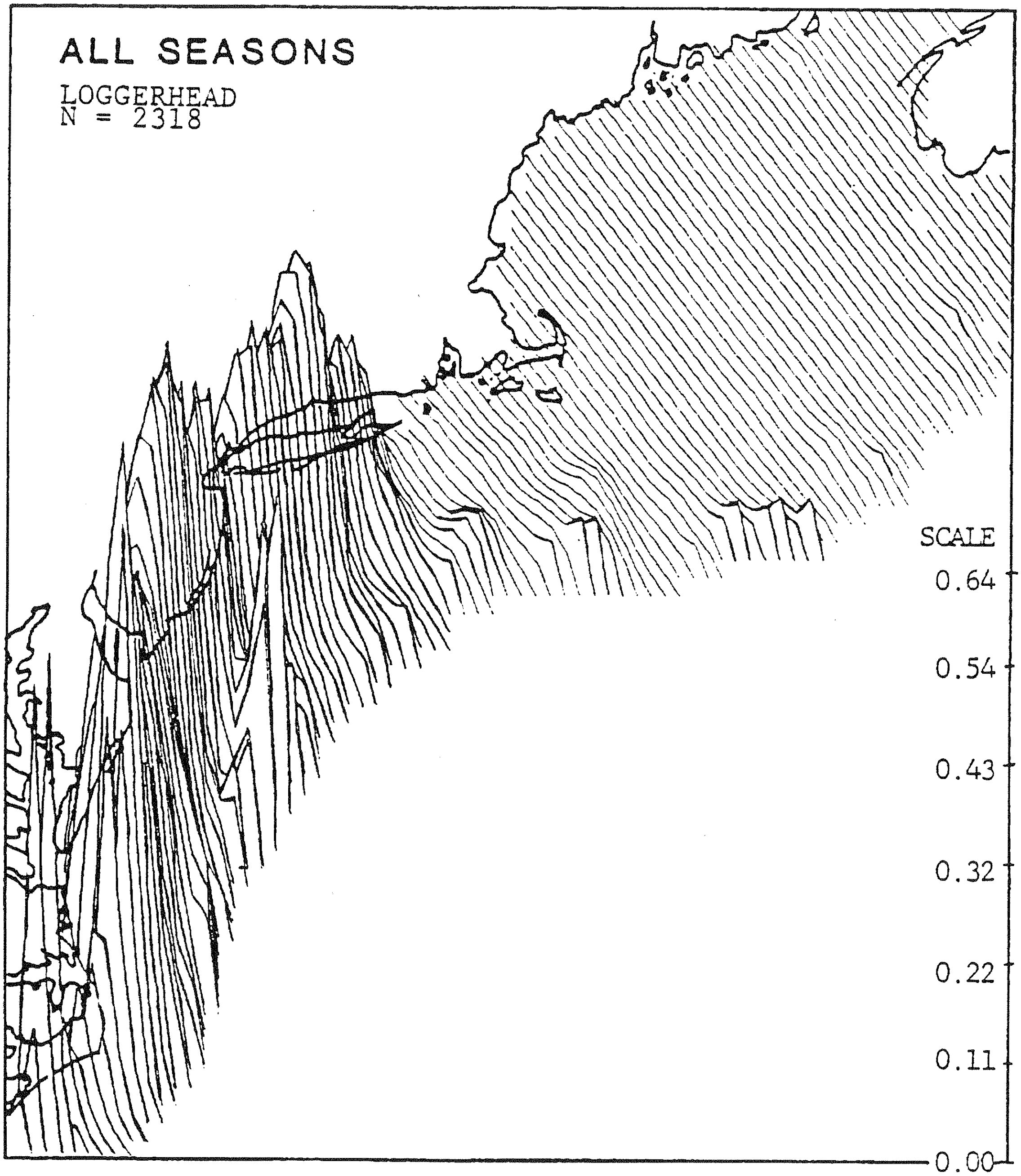

Figure 36b. The relative abundance of C. caretta for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

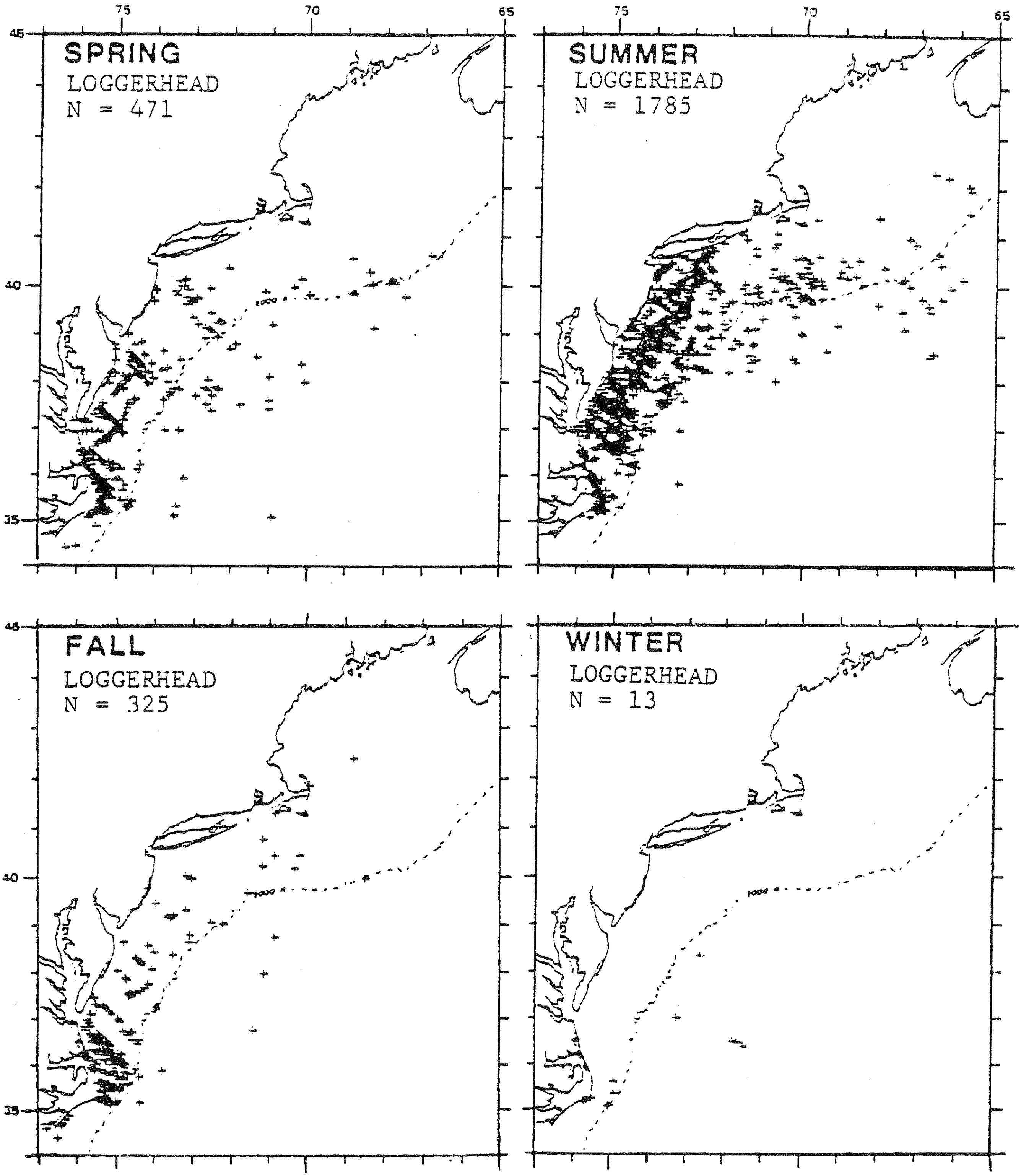

Figure 36c. The sighting distribution of C. caretta by season.

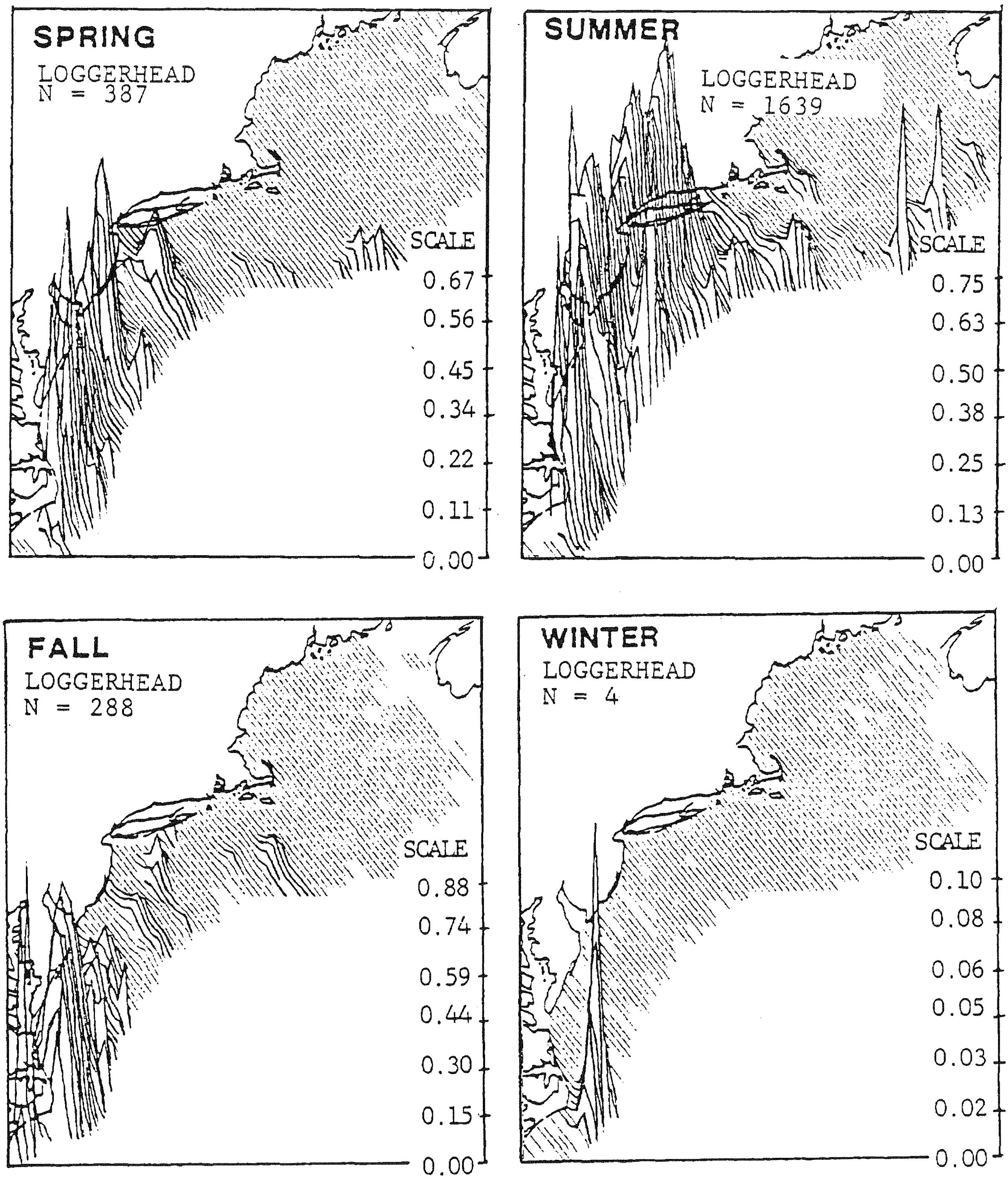

Figure 36d. The relative abundance of C. caretta by season. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function. Note that the plot scale differs between seasons and must be taken into consideration when interpreting these data.

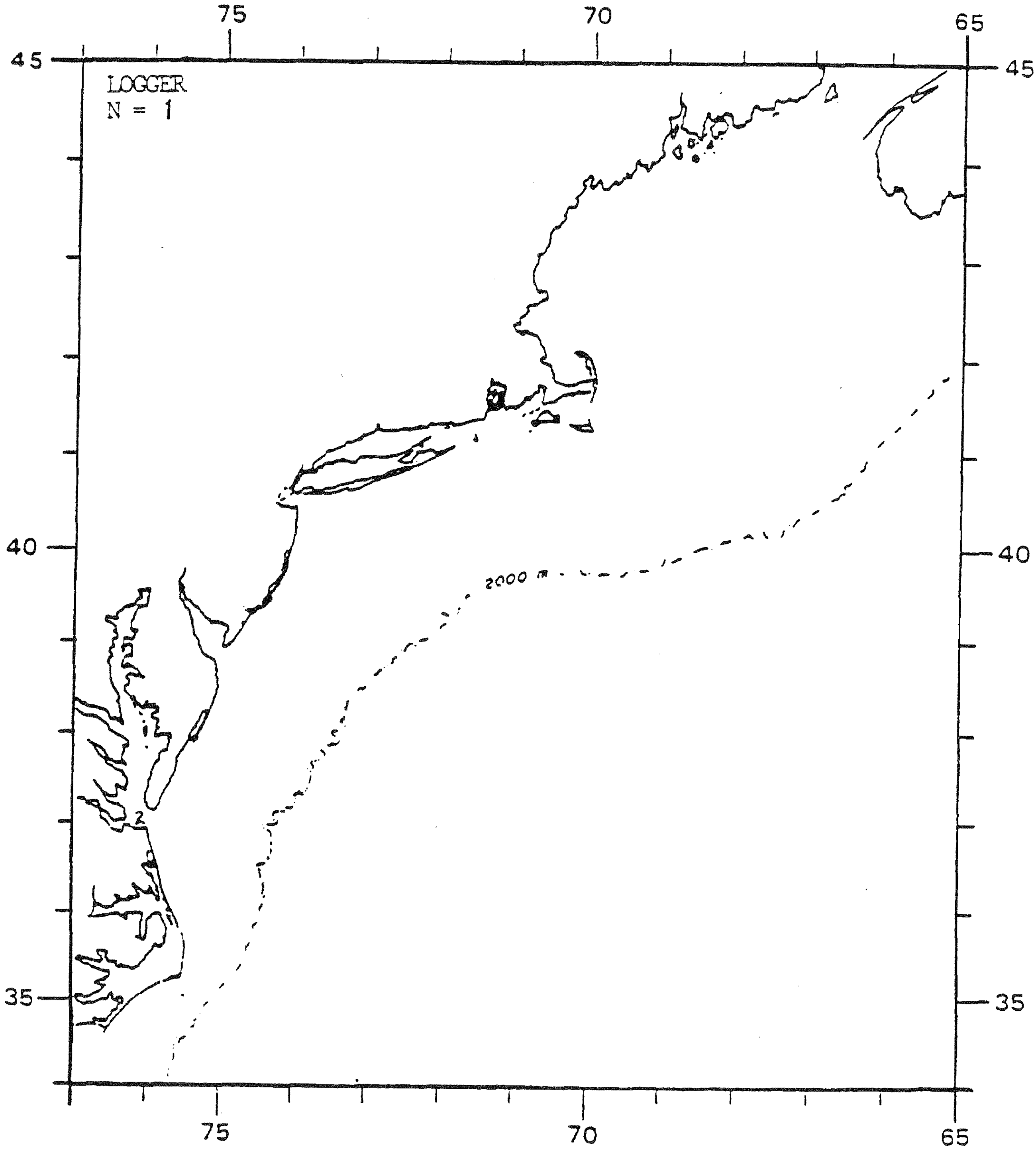

Figure 36e. Locations of sightings of feeding or apparent feeding of <u>C. caretta</u>. The numbers indicate the season of observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location

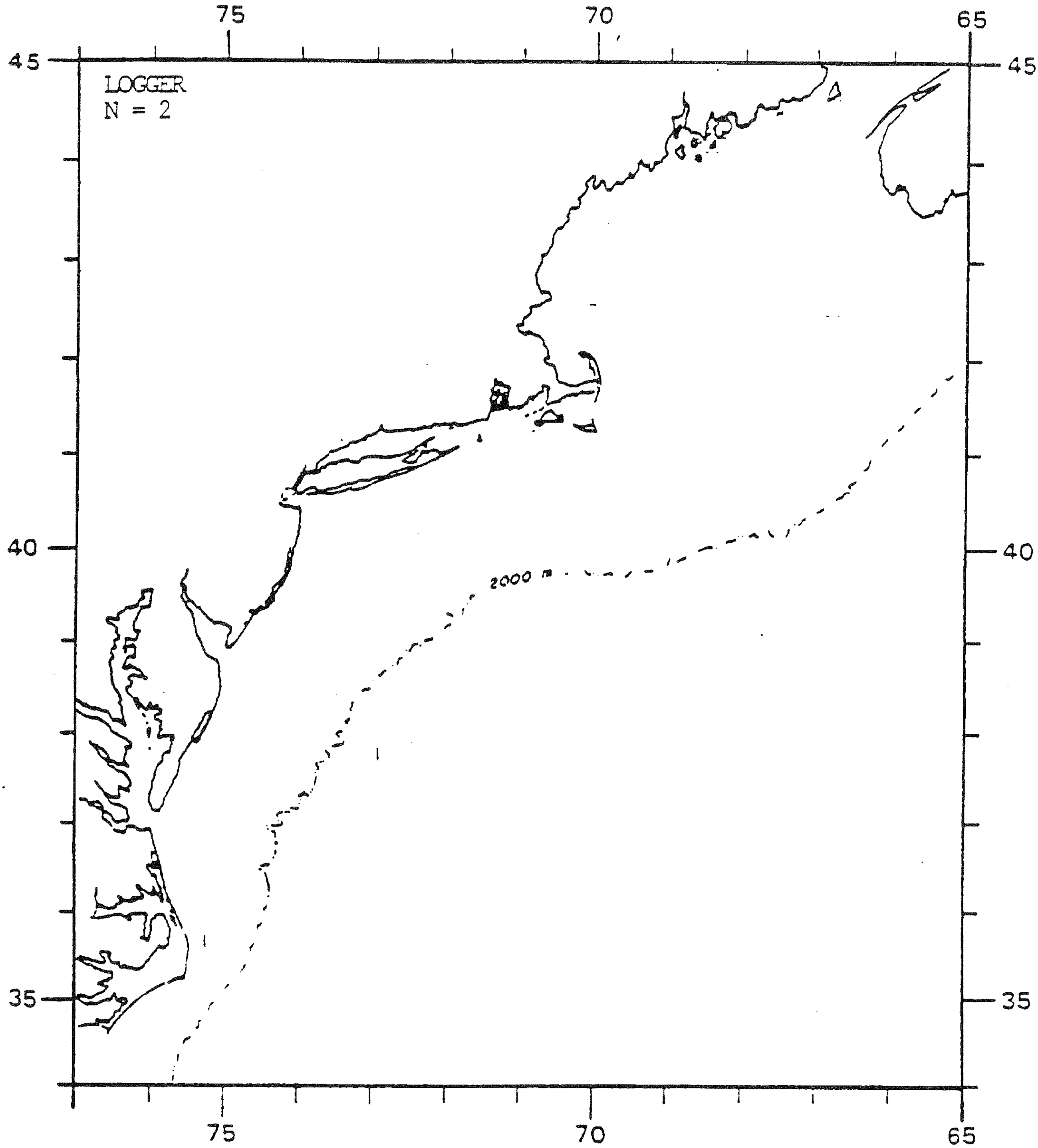

Figure 36f. Sightings of hatchlings or juveniles of C. caretta. The numbers indicate the season of the observation (1 = spring, 2 = summer, 3 = fall, 4 = winter) and are plotted at the sighting location.

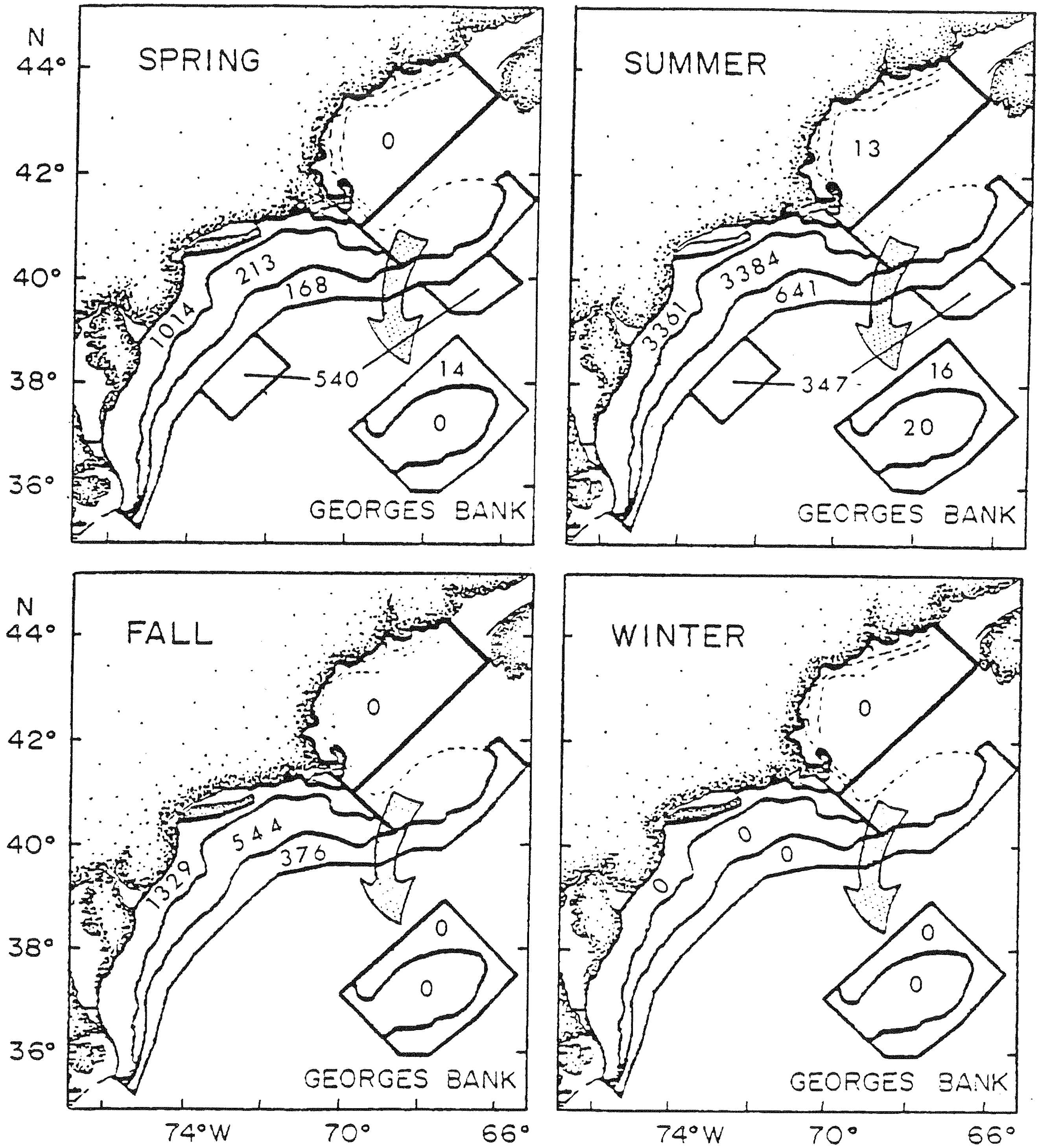

Figure 36g. Estimates of the number of individuals of C. caretta by season for selected regions. The estimates are averages based on all samples taken within the given region and season during the 39 month period -- 1 November 1978 through 28 January 1982. The complete data for all defined regions are given in the following table.

Table 24. Average density (individuals/km^2), variance of the density estimated number, and 95% confidence interval by defined region and season for *Caretta caretta*.

REGION	SPRING	SUMMER	FALL	WINTER
	SEASON			
GULF OF MAINE	0.00E+00	1.75E-04	0.00E+00	0.00E+00
	0.00E+00	3.73E-06	0.00E+00	0.00E+00
	0	13	0	0
	± 0	± 63	± 0	± 0
GEORGES BANK	1.87E-04	5.39E-04	0.00E+00	0.00E+00
	6.03E-07	3.03E-06	0.00E+00	0.00E+00
	13	37	0	0
	± 18	± 46	± 0	± 0
<50 FATHOMS	0.00E+00	6.22E-04	0.00E+00	0.00E+00
	0.00E+00	3.31E-06	0.00E+00	0.00E+00
	0	20	0	0
	± 0	± 34	± 0	± 0
>50 FATHOMS	3.94E-04	4.42E-04	0.00E+00	0.00E+00
	1.27E-06	2.71E-06	0.00E+00	0.00E+00
	14	16	0	0
	± 21	± 33	± 0	± 0
LEASE SALE 52	8.31E-04	7.84E-03	4.37E-04	0.00E+00
	3.27E-06	7.25E-05	1.33E-06	0.00E+00
	23	219	12	0
	± 26	± 144	± 34	± 0
MID-ATLANTIC	9.79E-03	5.25E-02	1.61E-02	0.00E+00
	3.50E-04	2.00E-03	6.49E-04	0.00E+00
	1343	7210	2204	0
	± 620	± 1667	± 1045	± 0
NEAR SHORE	2.49E-02	8.24E-02	3.26E-02	0.00E+00
	1.10E-03	3.42E-03	1.46E-03	0.00E+00
	1014	3361	1329	0
	± 585	± 1227	± 864	± 0
MID-SHELF	4.06E-03	6.46E-02	1.04E-02	0.00E+00
	8.23E-05	2.54E-03	3.98E-04	0.00E+00
	213	3384	544	0
	± 205	± 1357	± 578	± 0
NEW YORK BIGHT	3.55E-03	5.13E-02	1.74E-03	0.00E+00
	3.88E-06	1.61E-03	1.29E-05	0.00E+00
	220	3179	108	0
	± 50	± 1103	± 115	± 0
SHELF EDGE	2.70E-03	1.03E-02	6.05E-03	0.00E+00
	2.49E-05	1.38E-04	9.21E-05	0.00E+00
	168	641	376	0
	± 120	± 301	± 360	± 0
CONTINENTAL SLOPE	1.75E-02	1.12E-02	.	.
	8.22E-05	5.21E-05	.	.
	540	347	.	.
	± 234	± 2001	± .	± .
STUDY AREA OCS*	1464	7702	2927	0
	± 661	± 1748	± 1374	± 0

*Study area OCS does not include the slope water regions.

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Chelonia mydas - Green turtle - Endangered/Threatened Species

INTRODUCTION

Endangered Species Status. The Florida population of the green turtle is listed as endangered, while other populations are listed as threatened. Since it is not known which nesting population(s) the green turtles in the study area are drawn from, a distinction as to whether they are endangered or threatened is not possible.

1981 Data. The green sea turtle was not observed during the 1981 field surveys.

Number of Sightings. *C. mydas* was observed on 7 occasions during the 3 year field effort. However, only 4 sightings were made from aerial platforms in the study area. All of these were "unsure or probable" rankings of the identification reliability scale. The only "sure" sightings were of stranded or trapped animals along the shore in Cape Cod Bay, MA, Rhode Island and New York waters. The species is probably the least common sea turtle in the area although it was once more common from Long Island southward (Hornaday, 1904).

Individuals per Sighting. Only one individual was observed at each sighting.

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SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. Scattered and widely distributed sightings of green sea turtles were reported from the waters overlying the continental shelf southward from Long Island (Figures 37a and b). Additional unpublished data (C.R. Shoop-Univ. of Rhode Island, personal communication) indicates that incidentally captured or stranded *C. mydas* are known from Cape Cod Bay as well as from the waters of both Block Island and Long Island Sounds. It is generally assumed that the green sea turtle is distributionally limited by water temperature, so that the northern limit of this species distribution occurs during the warmer summer months where surface water temperatures reach their maximum. Therefore, when water temperatures permit, green sea turtles may be observed over areas of the continental shelf from Cape Cod southward. Furthermore, their distribution shows preference for shallower areas of the shelf with only one sighting reported from waters greater than 46 meters.

Hatchlings/Juveniles. No immature *C. mydas* was observed during any CETAP survey. However, a single, immature green turtle was captured, tagged, and released near Newport, RI in August 1981 (C.R. Shoop - URI, unpublished data). This individual was subsequently caught and released from a net near Long Island, NY one month later.

Feeding. While all green turtles observed in the study area appeared in excellent physical condition, none were directly observed feeding.

Areas. Green turtles were not observed in any designated base area. However, it can be assumed that because this species is strongly herbivorous that coastal lagoons, estuaries, and other shallow areas provide feeding locations for C. mydas observed within the study area.

POPULATION ESTIMATES AND STATUS

Population Estimates. The paucity of sightings of the species over the 3 year field effort did not provide sufficient data to allow for the construction of an estimate of the numbers of this species occurring in the study area. The Florida population holds endangered status, while other populations are classified as threatened.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth (m). The mean water depth recorded at sightings of green turtles was 437.5m with a range from 0 to 2926m. The high mean value belies the fact that only one sighting was reported at a depth greater than 46m (namely, 2926m). With a total of only 7 sightings, a single deep water sighting has pronounced effect on the mean. In fact too few data are available from this region to draw any conclusions with respect to depth preference in the study area.

BEHAVIOR

Migration and Movement. All green turtles observed in the study area are migrants from more southerly locations. Except for a lone report of a nesting female in North Carolina, the closest substantial nesting populations occur in Florida. The pathway(s) used by C. mydas during its northward movement and subsequent southerly return trip remain unknown.

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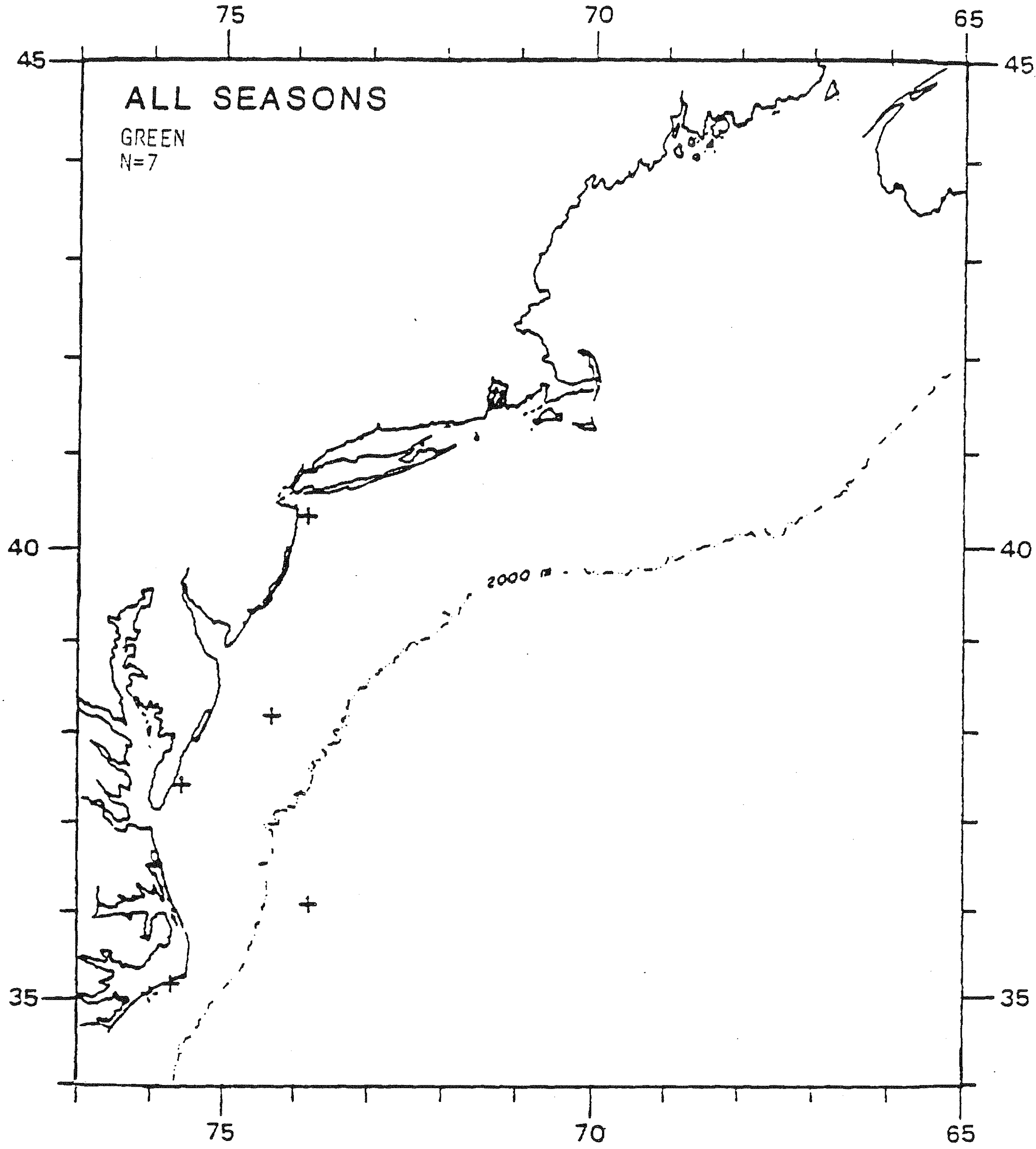

Figure 37a. All sightings of the green turtle, <u>Chelonia mydas</u>, for the 39 month period -- 1 November 1978 through 28 January 1982.

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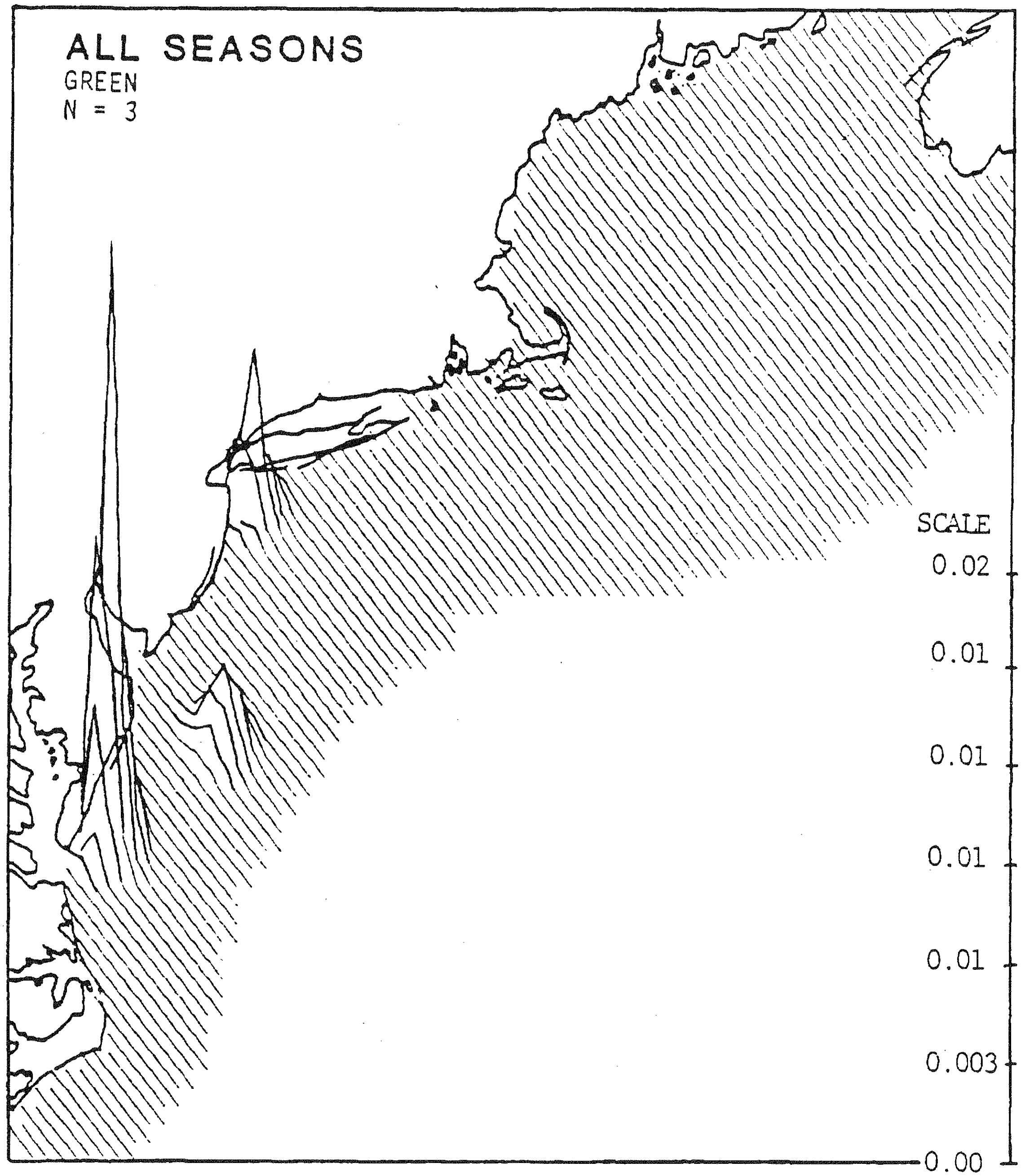

Figure 37b. The relative abundance of C. mydas for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

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Lepidochelys kempi - Kemp's Ridley turtle - Endangered Species

INTRODUCTION

1981 Data. Kemp's ridley turtle was not observed during 1981 CETAP surveys. Stranding reports (C.R. Shoop - URI, unpublished data) from an area compatible with that used by CETAP for 1981 do, however, conform to previous CETAP reports.

Number of Sightings. During the 3 year survey period, _L. kempi_ was sighted on 6 occasions totaling 6 individuals. Five of these sightings report identification reliabilities of "unsure" or "probable" for the species involved. The lone "sure" sighting involved a stranded ridley. Since there were no "sure" sightings from off-shore areas, any conclusions based on these data concerning this species should be based on the "sure" sightings of stranded animals.

Individual per Sighting. All sightings of this species reported only one individual present.

SPATIAL AND TEMPORAL DISTRIBUTIONS

General Distribution. The distribution of _L. kempi_ within the study area is poorly understood. Known almost exclusively through strandings, ridley turtles are known to occur as far north as Cape Cod. Additional stranding reports from Canada (Brongersma, 1972) confirmed that northern limit for this species may extends farther north. Within the study area, Figures 38a and b depict sighting

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locations of ridley turtles. While the single deep water record of this species is dubious, it is reported in an attempt to present all available information.

Hatchlings and Juveniles. All sightings of this species during CETAP surveys were probably of immature/juvenile animals since adults are unknown on the U.S. Atlantic coast and all stranded animals have been juveniles; thus Figure 38a also represents the distribution of juvenile *L. kempi*.

Feeding. During the 3 year field surveys, *L. kempi* was not observed feeding during any sighting.

Areas. Two regions within the study area, Cape Cod Bay and Chesapeake Bay, are known to be occupied (through reports of stranded specimens) by Kemp's ridley turtles during some portion of the year.
L. kempi was not observed in any current Lease Area. Since juvenile Kemp's ridley turtles are believed to feed in shallow, estuarine habitats, residence in Lease Areas may be unlikely.

POPULATION ESTIMATES AND STATUS

Population Estimates. Too few data are present to enable accurate population estimates to be generated. Meylen and Carr (1980) estimated that fewer than 1000 adults comprise the entire species population in the single known nesting area in Mexico.

ENVIRONMENTAL DATA

Water Temperature (°C). Sea surface temperature was not available for any of the sightings of this species.

Depth. The mean water depth recorded at sightings of ridley turtles was 520.3m with a range from 0 to 2972 meters. The large mean value is attributable to one deep-water sighting (2972 meters), but overlooks the fact that only one sighting was recorded in water deeper than 62 meters.

BEHAVIOR

Migration and Movement. Since *L. kempi* nests in a single area in Mexico, all ridley turtles occurring in the study area are migrants. While migrations of this species to northeastern U.S. waters have long been known (Carr, 1952), the reasons for this migration and the route(s) used are currently unknown. Adults of this species are unknown along the U.S. Atlantic shore.

L. kempi movements into and out of the study area appear to coincide with increasing and decreasing surface water temperatures. Apparently some individuals are "trapped" by the geography of Cape Cod Bay during their return to southern waters. This could account for their resulting death by hypothermia during autumn as confirmed by 1981 strandings (C.R. Shoop - URI, unpublished data). In general, the utilization of the northeastern U.S. continental shelf waters by Kemp's ridley turtle remains unknown.

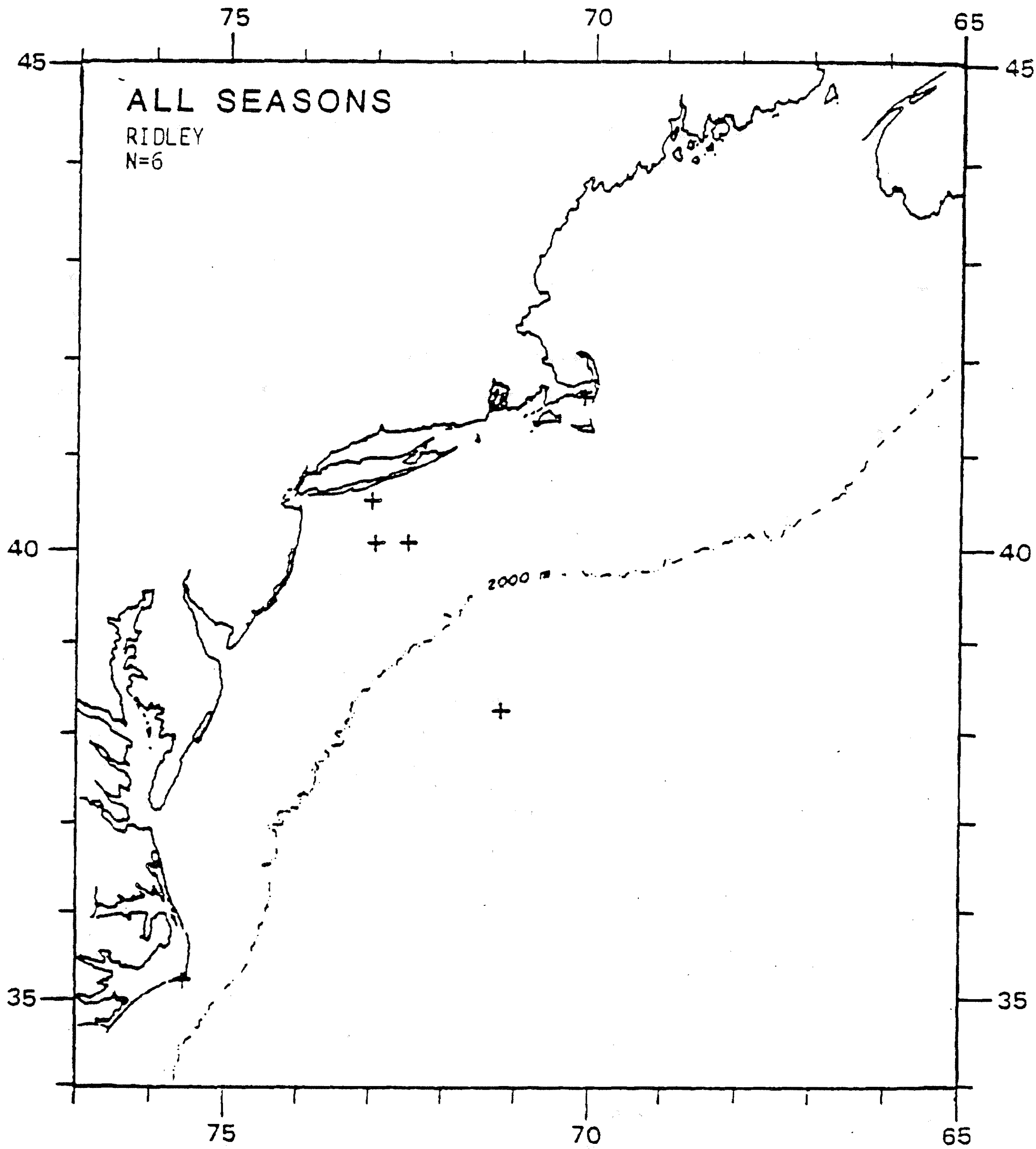

Figure 38a. All sightings of the Kemp's ridley turtle, *Lepidochelys kempi*, for the 39 month period -- 1 November 1978 through 28 January 1982.

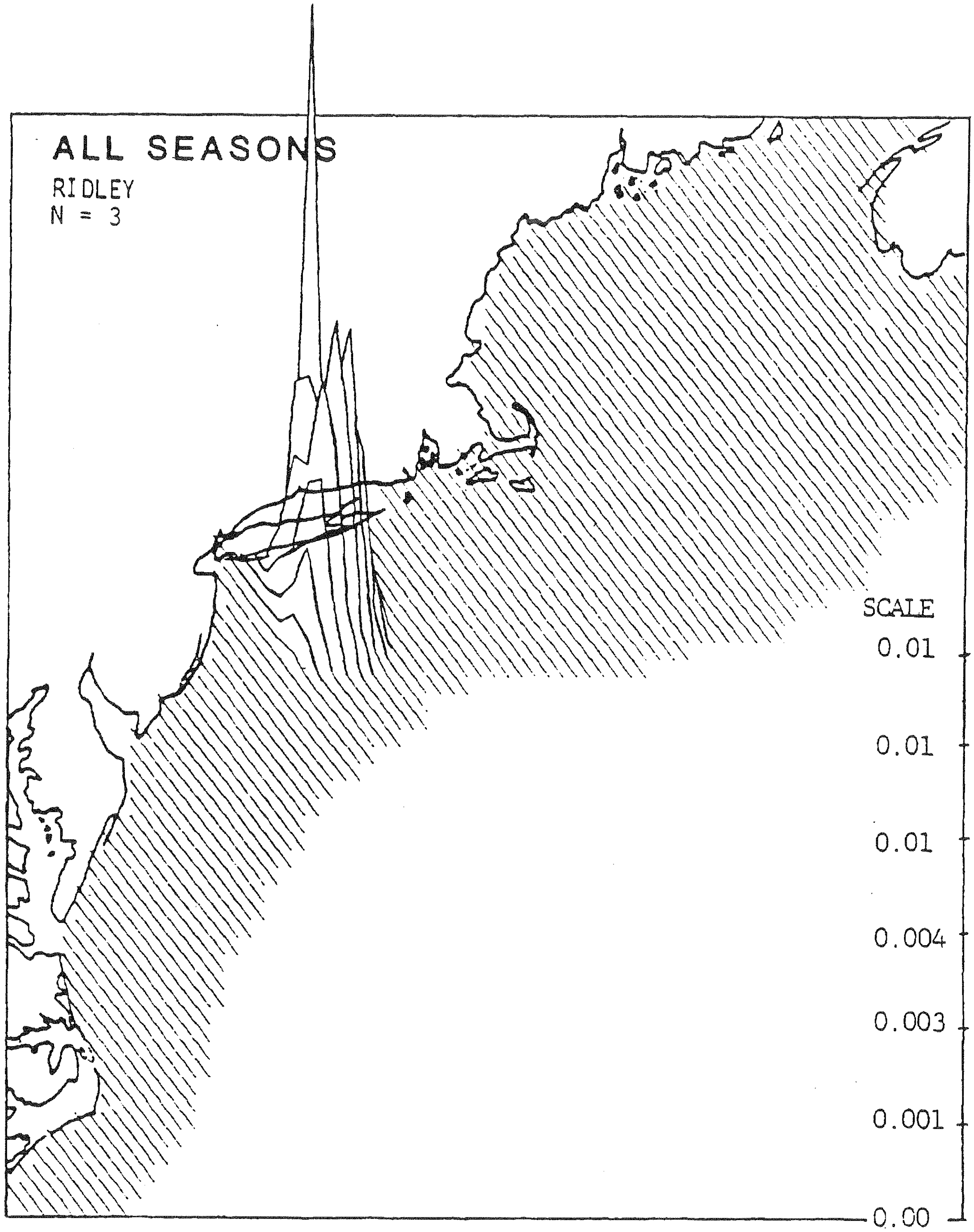

Figure 38b. The relative abundance of L. kempi for the 39 month period -- 1 November 1978 through 28 January 1982. Values plotted are the number of individuals per unit effort for each 10' quadrat within the study area after application of a binomial smoothing function.

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CETACEANS AND TURTLES IN THE STUDY AREA: A GENERAL OVERVIEW

Summary of Species Sighted. During the 39 months of CETAP field studies, 26 distinct species or species groupings of cetaceans and 4 species of marine turtles were sighted in or nearby the study area. These are listed in Table 25.

Cetaceans. The cetacean sighting data consisted of 11,156 sightings of 170,012 individuals of 26 species. Table 26 lists the species sighted, the number of sightings, and the number of individuals for each. The species listed are arranged in order of sighting frequency -- from those most commonly sighted to those rarely sighted. Of the large whales, fin whales (B.physalus) and humpback whales (M.novaeangliae) were the more common species. Of the small whales, the bottlenosed dolphin (T.truncatus), harbor porpoise (P.phocoena), whitesided dolphin (L.acutus), pilot whales (Globicephala spp.), grampus (G.griseus), and the saddleback dolphin (D.delphis) were the more common. The CETAP results included important new findings on endangered species, among them the right whale (E.glacialis) and the sei whale (B. borealis), and gave unique, and often the only live-sighting data on several uncommon or rare species, beaked whales for example (Z.cavirostris and Mesoplodon spp.) Details are found in the respective species accounts.

Throughout the field studies, not all cetacean sightings have been identifiable to species. Of the total sightings, approximately 23% were not identified to the species level. This percentage is made up of 998 sightings of large whales (1743 individuals) and 1520 sightings of small whales (48,180 individuals). Therefore, the species accounts in the previous section represent 77% of the total cetacean sightings. Given the behavior of the animals, the interplay of weather and sighting conditions, and the inherent nature of biological sampling, these results are neither unexpected nor atypical.

An additional summary of cetacean sighting data is given in Table 27. There, the data are summarized for each of the three years of the field studies program.

Turtles. Over the course of the CETAP field studies, 2820 sightings totalling 3180 individuals of 4 species of marine turtles were recorded. Table 28 provides the details.

Table 25. List of species or species groups seen in or nearby the study area during CETAP field studies.

Cetaceans

_Eubalaena glacialis_*
_Megaptera novaeangliae_*
_Balaenoptera physalus_*
_B. borealis_*
B. acutorostrata
_B. musculus_*°
_Physeter catodon_*
Orcinus orca
Hyperoodon ampullatus
Tursiops truncatus
Lagenorhynchus acutus
L. albirostris
Globicephala spp.
Grampus griseus
Delphinus delphis
Stenella spp. (spotted)
Stenella coeruleoalba
Stenella longirostris
Mesoplodon spp.
Ziphius cavirostris
Pseudorca crassidens
Feresa attenuata
Kogia spp.
Steno bredanensis°
Delphinapterus leucas
Phocoena phocoena

Turtles

_Dermochelys coriacea_*
Caretta caretta+
Chelonia mydas+
_Lepidochelys kempi_*

Key:

* Endangered Species
+ Threatened Species
° Not sighted within the study area

Table 26. Cetacean sighting summary. Includes all sightings made during the 39 month CETAP field studies in and adjacent to the study area.

Baleen whales (mysticetes)	No. of Sightings	No. of Individuals	Toothed whales (odontocetes)	No. of Sightings	No. of Individuals
Common Species					
Balaenoptera physalus	2047	5875	*Tursiops truncatus*	1025	15133
Megaptera novaeangliae	1026	2793	*Phocoena phocoena*	778	2246
Balaenoptera acutorostrata	518	782	*Globicephala* spp.	619	12438
Eubalaena glacialis	380	988	*Lagenorhynchus acutus*	584	31276
Balaenoptera borealis	67	204	*Grampus griseus*	479	8264
			Delphinus delphis	453	24708
			Physeter catodon	341	1034
			Stenella spp. (spotted)	126	6044
			Stenella coeruleoalba	114	7404
Subtotal	4038	10642	Subtotal	4519	108547
Uncommon or Rare Species					
Balaenoptera musculus	2	2	*Lagenorhynchus albirostris*	33	523
			Mesoplodon spp.	13	39
			Orcinus orca	12	85
			Ziphius cavirostris	6	16
			Delphinapterus leucas	5	7
			Stenella longirostris	4	170
			Hyperoodon ampullatus	2	3
			Pseudorca crassidens	1	7
			Feresa attenuata	1	2
			Kogia spp.	1	1
			Steno bredanensis	1	45
Subtotal	2	2	Subtotal	79	898
Total Baleen Whales	4040	10644	Total Toothed Whales	4598	109445
Total Unidentified or Partially Identified Cetaceans				2518	49923
Grand Total - Cetacean Sightings from CETAP Field Studies				11156	170012

Table 27. Cetacean sighting summary by year, for the CETAP field studies over the Mid- and North Atlantic OCS.

Species	1979 No. of Sightings	1979 No. of Individuals	1980 No. of Sightings	1980 No. of Individuals	1981 No. of Sightings	1981 No. of Individuals
Baleen whales (mysticetes)						
Balaenoptera physalus	913	2722	794	2200	340	953
Megaptera novaeangliae	532	1328	349	1152	145	313
Balaenoptera acutorostrata	271	437	167	254	80	91
Eubalaena glacialis	144	248	98	320	138	420
Balaenoptera borealis	7	16	50	167	10	21
Balaenoptera musculus	0	0	2	2	0	0
Subtotal	1867	4751	1460	4095	713	1798
Toothed whales (odontocetes)						
Tursiops truncatus	588	7757	345	5549	92	1827
Phocoena phocoena	402	1406	281	675	95	165
Globicephala spp.	319	6339	209	4742	91	1357
Lagenorhynchus acutus	226	12143	242	12147	116	6986
Grampus griseus	209	4278	177	2541	93	1445
Delphinus delphis	193	8789	126	7358	134	8561
Physeter catodon	150	493	108	245	83	296
Stenella spp. (spotted)	87	5254	37	670	2	120
Stenella coeruleoalba	71	4387	40	2372	3	645
Lagenorhynchus albirostris	25	412	7	110	1	1
Mesoplodon spp.	1	3	10	32	2	4
Orcinus orca	5	53	3	6	4	26
Ziphius cavirostris	3	9	3	7	0	0
Delphinapterus leucas	2	4	3	3	0	0
Stenella longirostris	2	90	0	0	2	80
Hyperoodon ampullatus	0	0	1	1	1	2
Pseudorca crassidens	0	0	1	7	0	0
Feresa attenuata	0	0	0	0	1	2
Kogia spp.	0	0	0	0	1	1
Steno bredanensis	1	45	0	0	0	0
Subtotal	2284	51462	1593	36465	721	21518
Unidentified Large Whales	753	1297	190	330	55	116
Unidentified Small Whales	770	21198	446	14320	284	12662
Subtotal	1523	22495	656	14650	339	12778
Grand Total	5674	78708	3709	55210	1773	36094

Table 28. Summary of sighting data, for marine turtles recorded in and adjacent to the study area by CETAP from 1 November 1978 through 28 January 1982.

Species	*Dermochelys coriacea*	*Caretta caretta*	*Chelonia mydas*	*Lepidochelys kempi*	Unidentified marine turtle	Row Total
Common Name	Leatherback	Loggerhead	Green	Kemp's ridley		
1979						
No. of sightings	73	984	3	3	61	1124
No. of individuals	90	1203	3	3	67	1366
1980						
No. of sightings	30	1327	4	3	27	1391
No. of individuals	33	1432	4	3	29	1501
1981						
No. of sightings	19	283	0	0	3	305
No. of individuals	19	291	0	0	3	313
Column total						
No. of sightings	122	2594	7	6	91	2820
No. of individuals	142	2926	7	6	99	3180

A SUMMARY OF CETACEAN DISTRIBUTION AND ECOLOGY

On pp. II-252 to II-259 of the 1979 CETAP Annual Report, a number of generalizations about cetacean distribution patterns in the study area were made. With two additional years of data, these conclusions can be updated.

Distribution and Depth Data. For the 14 common species of cetaceans in the study area, two general distribution patterns are indicated. The species can be divided into an on-shelf group (mean depth at sighting </= 200 m) and a shelf-edge group (mean depth at sighting > 200 m). This conclusion was arrived at through examination of the plotted sighting data as given in the species accounts, and through the analysis of the depth-at-sighting data shown in Table 29 and Figure 39. The resulting groupings are:

On-shelf	Shelf-edge
E. glacialis	*B. borealis*
M. novaeangliae	*P. catodon*
B. physalus	*T. truncatus*
B. acutorostrata	*Globicephala* spp.
L. acutus	*D. delphis*
P. phocoena	*G. griseis*
	Stenella spp. (spotted)
	S. coeruleoalba

These groupings are not along strictly taxonomic lines. While the on-shelf pattern is shared by most baleen whales, the pattern includes two odontocetes--*L.acutus* and *P.phocoena.* These findings are consistent with those in the 1979 CETAP Annual Report.

One finding new to this report, and not evident in the 1979 data concerns the sei whale, B. borealis. The sei whale appears to be unique among the baleen whales in its tendency for deep-water occurrence, and thus, is the only baleen whale in the grouping of shelf-edge cetaceans--a category composed almost exclusively of odontocetes. Even when the sei whale occurs in the Gulf of Maine, it is most often in the deeper water of the Northeast Channel and Georges Basin regions.

The separation of these hypothetical groupings was tested statistically. The six on-shelf species had a combined mean depth of 136+/-5 (SE) m. The eight shelf-edge species had a combined mean sighting depth of 987+/-19 (SE) m. There is a significant difference in mean sighting depths for these two groups (T test, $P < 0.0001$). Next, the hypothesis that L.acutus and P.phocoena differ in sighting depth from other common odontocetes was tested. The combined mean sighting depth for these two on-shelf odontocetes was 141+/-8 (SE) m. This was significantly different than that of other odontocetes (T test, $P < 0.0001$). No significant difference was found between these two species and the four common on-shelf baleen whale species. Lastly, the hypothesis that sei whales were more closely akin in their distribution to shelf-edge odontocetes than taxonomically-related baleen whales was tested. The mean sighting depth of 506+/- 88(SE) m was significantly different from that of the on-shelf baleen whales (T test, $P < 0.0001$).

The nature of these hypothetical groupings was tested further. Table 29 includes the results of Duncan's Multiple Range Test in sorting the 14 common cetacean species by depth-at-sighting data. The six on-shelf species were assigned to a single grouping with no significant difference between mean water depth. The eight shelf edge species do not form a group, but sort into individual species. An exception is the grouping of D. delphis and Globicephala spp. as two species having similar mean depths.

The hypothesis of two general cetacean distribution patterns--an "on-shelf" group consisting of four baleen whales, L. acutus and P. phocoena; and a shelf-edge" group consisting of seven odontoctes and the sei whale--is generally supported. The on-shelf cetaceans have more similar mean depths and generally low variability. This is suggestive of a high degree of distributional overlap and habitat sharing. On the other hand, the shelf-edge cetaceans have dissimilar mean depths and generally higher variability. While this suggests the distribution of the shelf-edge cetaceans is spread over a wider depth range, it may also indicate some degree of habitat partitioning or preference--where various species tend to occupy a given depth region along the shelf edge. The distributional data for D.delphinus, for example, are consistent with this hypothesis, as this species appears to occur inshore of most shelf-edge species.

Of the shelf-edge odontocetes, there is also some distinction as to north-south distribution. Pilot whales are a most abundant odontocete in northern waters and similarly abundant in the southern section of the Mid-Atlantic Bight. An apparent discontinuity in the distribution in the area near the Hudson Canyon may represent the division between the ranges of the two species. D.delphis are widely spread along the shelf edge throughout the study area. P.catodon is likewise widely distributed, but has it's greater abundances in the Mid-Atlantic Bight. This characteristic is even more distinct in G.griseus, a species that strongly favors the Mid-Atlantic Bight. This is likewise true for S.coeruleoalba. The most southern of the odontocetes are spotted dolphins, Stenella spp. (spotted), which commonly occur only in the southernmost portion of the study area. T.truncatus is unique in that it is widely distributed along the shelf-edge throughout the Mid- and North Atlantic region, but also has an area of high abundance around Cape Hatteras and northward, nearshore, to Cape Henlopen, DE. Because of this inshore/offshore distribution, Tursiops is also unique in that it cannot be accurately considered as either a primarily "on-shelf" or "shelf-edge" species.

Temperature Data. The surface water temperature at sighting location data were also examined for possible patterns (Figure 40). Almost all species were sighted in a wide range of water temperatures. However, analyses of the data also is suggestive of a general pattern--consistent with the distributional data. The more northern and on-shelf species were found more frequently in cooler waters. The more southerly and offshore species were characterized by warmer average water temperatures.

The mean average temperatures arranged from low to high reflect the distribution of the species. For example, while the sei whale appears to be predominantly a shelf-edge species, its exclusively northerly range results in the cooler water temperatures similar to the characteristic lower values of the on-shelf species. Again, L.acutus and P.phocoena are similar to the on-shelf baleen whales. D.delphis, a shelf-edge odontocete, is distinct with regard to temperature data due to its year-round and northerly occurrence. The southerly distribution of grampus and spotted dolphins are evident from their warm-water temperature data.

Group Size Data. The number of individuals recorded per sighting was used as an approximate measure of group size (the term approximate is applied as there was some variability in the data collection on this topic). As with most other characteristics examined, most species showed a wide range in group size. Statistical analysis, however, suggested a number of conclusions. These data are given in Figure 41, arranged from smallest to largest mean group size.

In general, the common large whales were found either alone or in small groups (mean of 2.7 +/-0.035 S.E.). The common small whales, all odontocetes, were found in larger groups (mean of 31.1+/-0.15 S.E.). An exception to this generalization is P.phocoena, an odontocete with a mean group size of 2.9 +/-0.16 S.E.

The smallest group size of any common cetacean was 1.5 +/-0.07 S.E. for minke whales. The largest was 64.9 +/- 8.1 S.E. for the striped dolphin, S. coeruleoalba.

In summary, most cetaceans display a wide range of values for whatever distributional or environmental data one might examine. However, analyses indicate that many species or species groupings can be characterized by geographic distribution, water depth, water temperature, and group size.

Table 29. Water depth at sighting location for common cetaceans in and adjacent to the study area. Data are from 39 month period 1 November 1978 through 28 January 1982, and are arranged by mean depth values. In the rightmost column, these species are assigned to groupings based on depth-at-sighting data using Duncan's Multiple Range Test. Where two or more species are assigned to the same grouping, their mean depths are not significantly different at p = 0.05.

Species	N	Mean Depth	SE	Range Central 90%		Duncan's Test Grouping
M.novaeangliae	469	95	8	20	174	A
P.phocoena	585	124	10	18	224	A
B.acutorostrata	234	133	21	18	606	A
E.glacialis	231	140	10	31	227	A
B.physalus	1079	149	10	27	256	A
L.acutus	432	165	13	38	271	A
B.borealis	63	506	88	49	2124	B
T.truncatus	824	677	27	7	2158	C
Globicephala spp.	553	821	37	46	2377	D
D.delphis	415	844	56	54	2983	D
G.griseus	461	1092	45	77	2743	E
Stenella spp.(spotted)	111	1250	135	19	3963	F
P.catodon	304	1804	57	74	3568	G
S.coeruleoalba	104	2076	103	101	3749	H

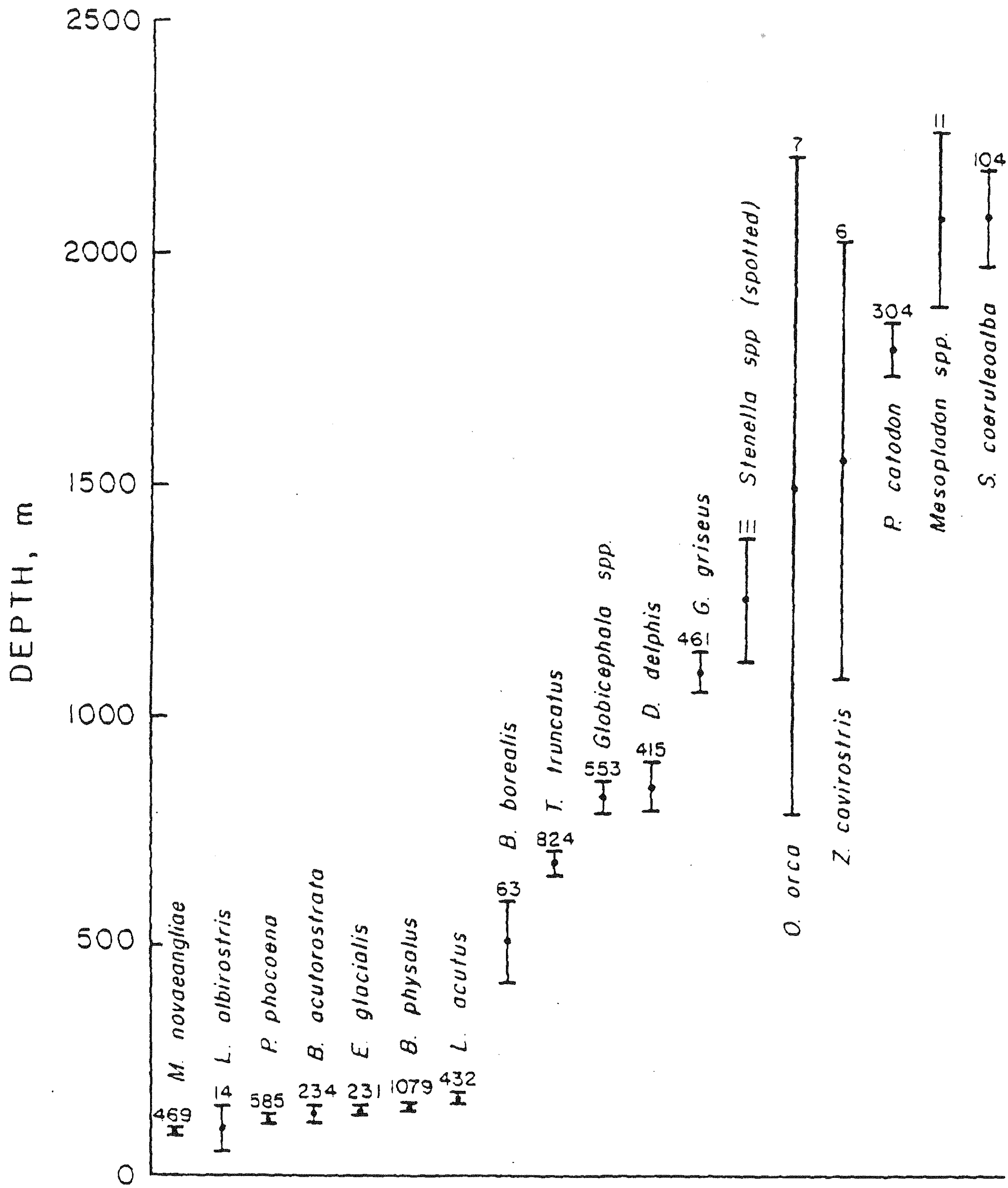

Figure 39. Water depth at sighting locations for common cetaceans. Data shown are mean depths with standard errors. Sample size is given above the error bars.

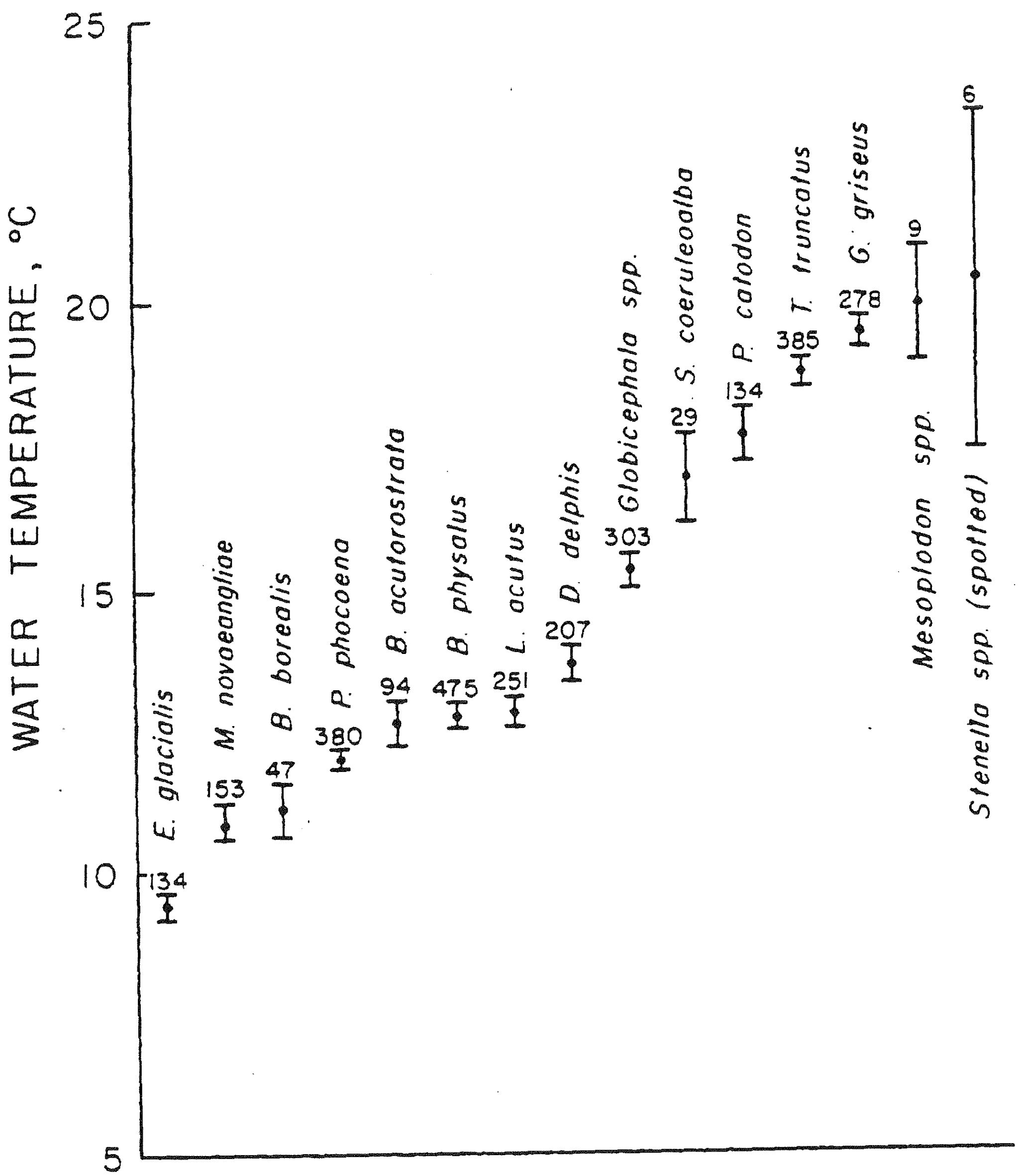

Figure 40. Water temperature at sighting locations for common cetaceans. Data shown are mean temperatures with standard errors. Sample size is given above the error bars.

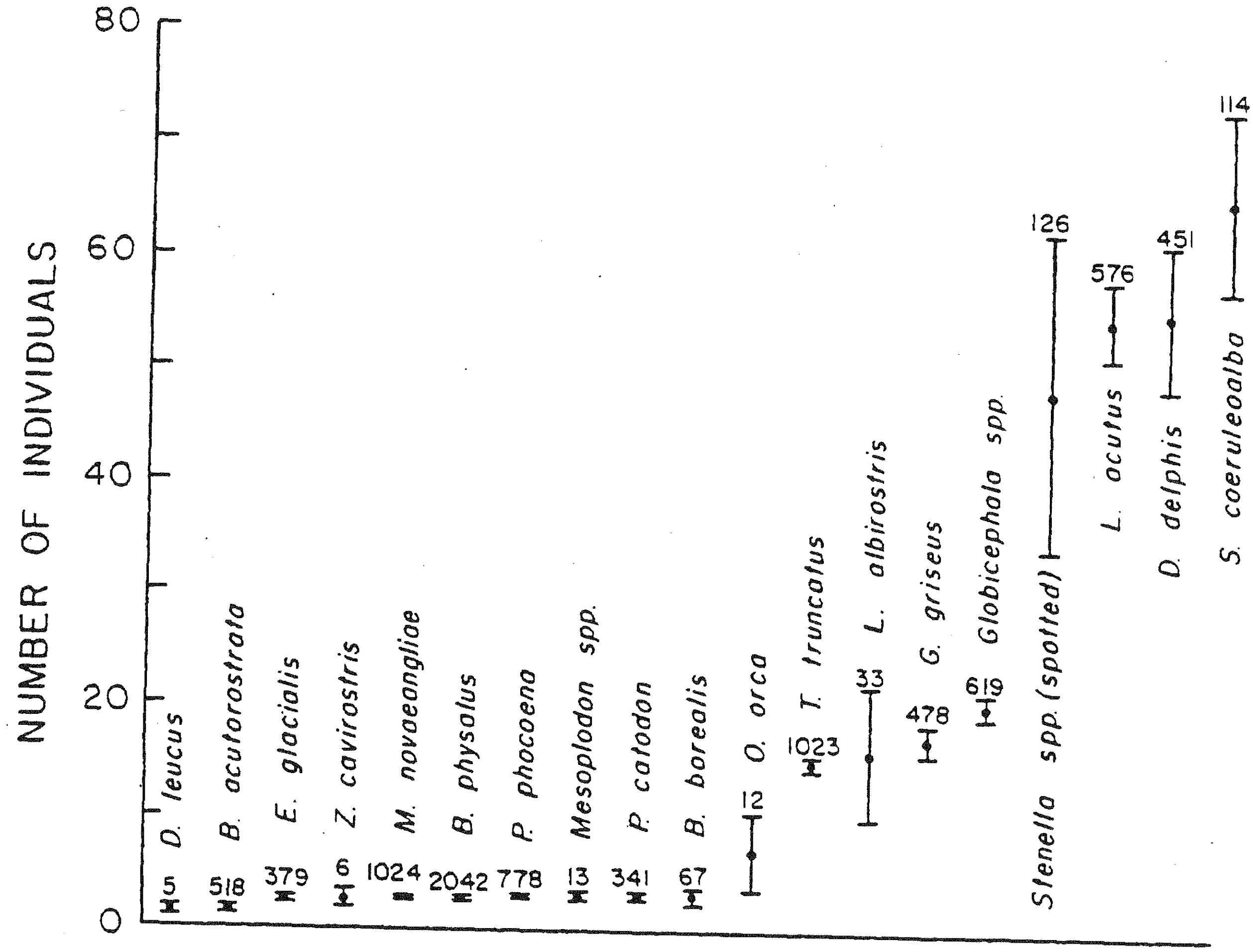

Figure 41. The number of individuals per sighting for common cetaceans. Data shown are means and standard errors. Sample size is given above the error bars.

CETACEAN BIOLOGY: THE MIGRATION QUESTION

Migration routes, behavior, and areas involved are among the most difficult of life history data to obtain. The preceding species accounts contain some data and hypotheses for testing. However, the fact remains that the migrations of cetaceans in the study area are not well described.

The data do indicate higher abundances in warm seasons and reduced abundances during cold seasons for most species. Some survey data and resight data document conclusively aspects of the migrations of several species (Katona, 1980; Winn et al., 1975; Winn et al., this report). However, for most species, little is known.

The CETAP data reveal two pertinent items of information:

1) In spite of low sighting effort, many species are present in the study area during winter. The magnitude of this occurrence is not well known, although data suggest it to be more substantial than generally believed prior to the CETAP surveys. These sightings could be due to early arrival and/or late departure of migrants. They could be due to individuals which themselves have migrated down from more northerly waters. They could be due to overwintering animals. Or, they could be due to some combination of the three.
2) Many species, and in particular odontocetes, are sighted regularly over the continental slope, rise, and deep ocean. The magnitude of this occurrence is difficult to gauge. What exchange may occur between the offshore area and the present study area is unknown.

In summary, the CETAP data have advanced considerably the understanding of cetaceans in the study area. The indications are, though, that for many species only a part of their life history is spent in these waters. The movements while there are not well described. Further, the portion of their life history external to the area, and the migrations which link the two are largely undescribed. These questions are in many ways central to the understanding of the biology of the species found off our coasts.

SUMMARY OF CETACEAN FEEDING DATA

Observations of feeding were limited only to surface feeding in the current study. Previous literature and reports of stomach contents indicate that all species of cetaceans in the current study also feed below the surface to various degrees. In the numerous species, sub-surface feeding is the dominant, if not exclusive, feeding mode. Hence, while surface feeding observations give positive indication of important feeding grounds within the study are, the lack of surface feeding observations cannot be taken as indicative of areas which are not important feeding grounds.

In virtually all the species in the current study, both mysticetes and odontocetes, it is highly likely that the animals feed to various degrees in all areas in which the respective species are observed in relative abundance. The energetics of smaller odontocetes, particularly delphinids, suggest that they feed daily. Various field and captive studies indicate that various species of delphinids consume as much as 10% of their body weight per day (Smith and Gaskin, 1974; Odell et al., 1975). With such a high caloric demand, it is unlikely that delphinids ever go more than a day or two without feeding. To our knowledge, there is no evidence of any prolonged fasting period for odontocetes; they do not have fat deposits that would allow any prolonged fasting. It is likely that they maintain a daily feeding schedule year round.

Mysticetes, on the other hand, do have a prolonged fasting period while on their winter breeding grounds. This has been firmly established for humpbacks, and right whales, and is likely for the fin and sei whales as well (Jonsgard, 1966). It is not known where minkes in the North Atlantic over-winter, and whether a similar fasting period occurs. Consequently, mysticete whales in general must consume and store enough food during their "summer" feeding period to last the entire year. Brodie (1975) has estimated feeding rates for fin whales at over 1 metric ton/day over a six month feeding season in the Northern Hemisphere. Thus it is probable that mysticetes in the current study area, which is part of their feeding grounds, are feeding nearly every day during spring through fall.

In summary then, both odontocetes and mysticetes would be expected to feed virtually every day while in the study area; year round for odontocetes and seasonally for the mysticetes. Therefore, each species of cetacean was likely feeding, either at the surface or below, in any area in which it was seen regularly in the current study.

Surface feeding observations comprised approximately 12% of the total sightings of all mysticete whales. Surface feeding sightings ranged from 13-15% of total sightings for humpbacks, fin and sei whales, while accounting for only 4% and 6% for minke and right whales, respectively. The latter two species apparently rely more on sub-surface feeding than the other three mysticete species. Humpbacks, fin whales, and minke whales utilized the same general areas for feeding. Of particular importance were the corridor ranging from the Great South Channel to Jeffreys Ledge along the 100 m contour and the region to the east-southeast of Montauk Point. Sei and right whales, although both prefer copepods for food and use similar "skimming" techniques to capture their prey, showed little overlap in their distributions. Right whales utilized the Great South Channel/Jeffreys Ledge corridor, Georges Bank and the southern half of the Gulf of Maine, while sei whales were basically limited to the deeper edges of Georges Bank and the Northeast Channel of the Gulf of Maine.

Surface feeding observations were much less frequent for odontocetes. Although total general sightings of odontocetes were greater than mysticetes, feeding observations accounted for only 1.8% of the total. This is due to the combined effects of: 1)the greater difficulty in correctly identifying feeding in the smaller odontocetes, and 2)the predominance of sub-surface feeding by odontocetes on fish and squid.

Feeding patterns in odontocetes in the current study were most easily described in two components. There was a group of three species: white-sided dolphins, white-beaked dolphins, and harbor porpoise, that fed primarily in the Gulf of Maine, Georges Bank, and the Great South Channel/Jeffreys Ledge corridor. These three species are all primarily northern in general distribution. A second grouping of all the remaining smaller dolphins and the larger sperm whale, fed primarily along the shelf break throughout the study area. Several species, e.g., common dolphins, pilot whales, and bottlenosed dolphins, extended up onto Georges Bank and the southern portion of the Great South Channel during spring/summer. Several species were limited primarily to only the southern portions of the shelf break, e.g., spinner and spotted dolphins. A possible sub-population of bottlenosed dolphins also fed inshore along the coast as far north as the Delmarva peninsula.

Certain regions of the study area stand out as exceptionally important feeding grounds, on the basis of both surface feeding observations and inferred sub-surface feeding. The Great South Channel/Jeffreys Ledge corridor was important for all mysticetes except the sei whale and numerous delphinids. The greatest number of surface feeding observations were found along this corridor. A second area of importance for mysticetes, on the basis of surface feeding, was the region to the east-southeast of Montauk Point. Interior, shallower portions of Georges Bank were particularly important for right and sei whales and numerous delphinids. The entire shelf break region was important for fin whales and almost all of the delphinids and the sperm whale.

There were obvious seasonal trends in the surface feeding observations. Approximately 90% of the feeding observations in mysticete whales occurred in spring/summer; only 1.5% occurred during winter. This is a result of the seasonal migration patterns of the mysticetes. Of odontocete surface feeding observations, 76% occurred during spring/summer. This is due, in part, to seasonal migrtory movements on the parts of some species, e.g., humpback whales, but is is also due in large part to the reduced effort in winter time due to adverse weather conditions.

The overlap of the Lease Areas with the feeding grounds of cetaceans in the current study varied with the different species in question. The major feeding areas of the humpback, fin, and minke were peripheral to Lease Area 42 and Proposed Area 52. An additional feeding area for fin whales was adjacent to areas 40, 49, and 59. The most important feeding area for these three species, i.e., the Great South Channel/Jeffreys Ledge corridor, lies directly to the northwest of Area 42 and Proposed Area 52. It is important to consider that clockwise currents on Georges Bank have a northwesterly component that lead from the Lease Areas 42 and 52 to this major feeding ground (Bumpus, 1976). Feeding grounds of right whales and sei whales are found within and directly to the west of Proposed Area 52. In addition, right whales feed to the north and northwest of Area 42 and Proposed Area 52.

The feeding areas of the three more northerly delphinids (harbor porpoise, white-sided dolphins, white-beaked dolphins) were also peripheral to Area 42 and Proposed Area 52. The closest feeding concentration was again the Great South Channel/Jeffreys Ledge corridor lying to the northwest of these two Lease Areas.

Lease Areas 40, 49, 59, 42 and Proposed Area 52 are found within the major feeding regions of the remaining delphinids and the sperm whales, i.e., along the shelf break. These species all feed primarily sub-surface on fish and squid found along the shelf break and adjacent waters. Area 42 and Proposed Area 52 are found within the major feeding ranges of common dolphins, pilot whales, bottlenosed dolphin, grampus, striped dolphins, and sperm whales. Areas 40, 49, and 59 are within the major feeding ranges of pilot whales, bottlenosed dolphins, grampus, spotted dolphins, striped dolphins, common dolphins, and sperm whales.

SUMMARY OF CETACEAN CALF SIGHTING DATA

Calves or juveniles of most species reported in Table 26 were sighted within the study area. In general, the number of these sightings reflected the number of overall sightings for the species. Likewise, the distribution of calf and juvenile sightings mirrored the overall species distribution. While the data do not suggest any specific nursery grounds or areas preferred by mother-calf pairs, Goodale (1982) reported some evidence which indicated that fin whale calf sightings were associated with slightly warmer than average water temperatures, and that humpback calf sightings were associated with shallower depths than average.

No births have been recorded within the study area. It is the general view that calving takes place during winter in southern or offshore waters for most species, followed by an immigration to, and dispersion within, the study area. There may be exceptions. For example, Watkins and Schevill (pers. comm.) suggest that some right whale calving may occur near Cape Cod during the winter. Also, the CETAP data for sightings of calves and juveniles for several species of odontocetes in the shelf edge region indicate calf sightings are widely-distributed in space and time. This indicates either a nearly continuous influx from outside the area, or that some or much of the calving of small odontocetes occurs along the shelf edge within the study area.

Calves or juveniles of 10 species of cetaceans have been sighted within Proposed Lease Sale Area 52. Of these, calves or juveniles of the endangered fin and sperm whales are sighted infrequently. This is likewise true for the minke whale and beaked whales (*Mesoplodon* spp. and *Z. cavirostris*). Calves or juveniles of *T. truncatus*, *D. delphis*, and *G. griseus* are commonly sighted within the area. Details are provided in the individual species accounts and in Table 32.

MULTISPECIES ASSOCIATIONS IN CETACEANS

Sightings of mixed species groups of cetaceans were frequently reported by CETAP observers. The term multispecies association is used to describe this occurrence , and is defined as two or more species of cetaceans occurring generally within a circle of a 1/4 mile radius, although at times greater distances are involved. The proximity and behavior suggest that an interaction or association is present, rather than merely a random occurrence of unlike species within a given area.

Groups of animals comprised of two or more spatially intermingled species occurred on the average of once in every eight cetacean sightings. Typical examples of these multispecies associations are mixed schools of Globicephala and Tursiops, dolphins bowriding larger whales, and feeding aggregations of several species of whales and dolphins. Of the 26 cetacean species observed during CETAP surveys, 16 took part to some degree in multispecies associations. A summary of associations and their frequencies is given in Table 30.

Multispecies associations have been previously noted for cetaceans. Sergeant and Fisher (1957) reported the association of the white-sided dolphin, L. acutus, with the pilot whale, as well as the association of unidentified dolphins with pilot whales. Brown (1961) reports other sightings of this type. Norris and Prescott (1961) report the very common association of bottlenosed dolphins (Tursiops sp.) with northeastern Pacific pilot whale schools. Wursig and Wursing (1978) report the mutual interaction of bottlenose dolphins with the southern right whale, Eubalaena glacialis.

Hypotheses to explain the formation of mixed species associations include chance encounters, increased foraging efficiency, and increased predator detection and avoidance (Norris and Dohl, 1980; Strusaker, 1981; Waser, 1982). Wursig and Wursig (1979) suggest that play may in many cases be the motivation behind the bowriding of large whales by dolphins. Many or most of these associations clearly do not occur by chance. Norris and Prescott (1961) have used the term "social parasitism" to account for various dolphin species that associate with other species that presumably have more efficient food-finding capabilities. They also report observations which indicate an awareness, contact, or communication between the species involved. Calves or juveniles of one or both species were often a part of the schools of Globicephala and Tursiops frequently seen by CETAP. This suggests that learning may be a component of this associative behavior. Additionally, the protection afforded juveniles may be enhanced by the overall increased school size.

While it is common to decribe and characterize on a species-by-species basis, these data point to another facet of cetacean biology--a community and ecosystem level of organization. Common and widespread multispecies associations are a reminder that this dimension is an essential component of the findings presented in this report.

Table 30. Frequency of multispecies associations, listed by species. Number of total sightings for each species appears at left of row headings. To use: locate key species to left of row; reading across, number indicates the frequency the species at column head was observed with key species. Note: non-cetacean species include: sharks, turtles, fish, pinnipeds, rays and ocean sunfish.

	B.physalus	M.novaeangliae	B.acutorostrata	P.catodon	E.glacialis	B.borealis	Unid. Large whale	T.truncatus	Globicephala spp.	L.acutus	P.phocoena	G.griseus	D.delphis	S.coeruleoalba	Stenella spp.(spotted)	L.albirostris	Unid. Dolphins	Other Non-cetacean species
(2047) B.physalus	-	207	80	0	18	3	31	5	4	94	9	5	5	0	0	3	44	27
(1026) M.novaeangliae	207	-	45	1	19	2	29	2	4	72	5	2	2	0	0	1	32	13
(518) B.acutorostrata	80	45	-	0	3	1	5	1	2	15	14	0	2	1	0	0	4	19
(341) P.catodon	0	1	0	-	0	0	4	5	5	0	0	3	3	2	1	0	6	9
(380) E.glacialis	18	19	3	0	-	3	10	0	2	15	1	0	0	0	0	0	9	6
(67) B.borealis	3	2	1	0	3	-	1	1	2	0	0	0	1	0	0	0	2	5
Unid. Large whale	31	29	5	4	10	1	-	4	6	12	1	0	2	0	2	0	X	X
(1025) T.truncatus	5	2	1	5	0	1	4	-	84	1	0	7	1	1	0	0	8	56
(619) Globicephala spp.	4	4	1	6	2	2	6	84	-	2	1	6	5	0	4	0	38	24
(584) L.acutus	94	72	15	0	15	0	12	1	2	-	7	1	1	0	0	1	4	10
(778) P.phocoena	9	5	14	0	1	0	1	0	1	7	-	1	0	0	0	1	0	18
(478) G.griseus	5	2	0	3	0	0	0	7	6	1	1	-	4	2	0	0	14	22
(453) D.delphis	5	2	2	3	0	1	2	1	5	1	0	4	-	5	0	1	13	6
(114) S.coeruleoalba	0	0	1	2	0	0	0	1	0	0	0	2	5	-	1	0	2	0
(126) Stenella spp. (spotted)	0	0	0	1	0	0	2	0	4	0	0	0	0	1	-	0	0	0
(33) L.albirostris	3	1	1	0	0	0	0	0	0	1	1	0	1	0	0	-	0	0
Unid. Dolphins	44	32	4	6	9	2	X	8	38	4	0	14	13	2	0	0	-	X
Other Non-cetacean species	27	13	19	9	6	5	X	56	24	10	18	22	6	0	0	0	X	-

RESULTS OF REPLICATE SURVEYS: SAMPLING AND ESTIMATION OF VARIANCE

The sampling design called for replicated sampling in blocks E, P, Q, and R during the spring 1981 surveys. Each area was to have been sampled three times, but not all replicates were successfully completed. Sampling areas which were successfully surveyed three or more times during spring 1981 included Ex, Ey, Ez, Py, and Pz. Block Qy was completed twice. In addition, three replicates each were flown in the two Endangered Species Survey blocks (E1 and E2) and in a smaller block within E2 where the R/V *Tioga* had located a concentration of right whales (block RW). All surveys in question were completed between 25 April and 2 June. The time period between completion of the first and last sample within an area ranged from 10 to 26 days. The population estimates calculated for each species for each set of replicate samples were compared, using 2-sample t-tests for each pair of replicates with non-zero densities. Only one case of significant differences between replicate samples was found. The density of *P. phocoena* in block Py on 8 May (point estimate +/- 95% CI = 926 +/- 663) was significantly higher ($p < 0.05$) than on either 27 (167 +/- 153) or 28 April (82 +/- 84). The two April samples were not significantly different.

The replicate samples were also used to refine the population estimates for the individual survey areas. Pooling the replicates from an area effectively increases sample size. This has the effect of increasing the degrees of freedom of the t-statistic and narrowing the confidence interval. The results of this procedure are shown in Table 31. In only six instances are the confidence limits now larger than the point estimate. Assuming some degree of stability in the population of a species in any area over the time period spanned by the replicate samples, these numbers should represent better estimates of the actual populations.

In summary, the replicate surveys were designed to examine sampling variability--given that the time between samples was sufficiently short to eliminate natural variability in the species abundance. The outcome was that point estimates varied substantially from one day to the next. Confidence intervals were broad in most cases. The by-product of the sampling was that pooling the data from the replicate surveys gave quite good abundance estimates. However, the replicate survey trials were imperfect. It is likely that the factor of natural variability was not altogether eliminated--as several of the time intervals between samples were somewhat long. There are also sources of variability which have not been adequately accounted for in this analysis, e.g., sighting conditions and animal behavior. All these factors affect the estimates and resulting conclusions. Bearing this in mind, the present data confirm what has been previously indicated--sampling variance is often high and precision low. This is a problem inherent in sampling and estimating the abundance of marine mammals. If one wishes estimates with good precision, a higher percentage of an area must be sampled on a given day (and thus the size of the area sampled per day reduced), or closely spaced replicate samples taken and the data pooled.

Table 31. Estimated abundance, and 95% confidence interval about the estimate, for cetacean and sea turtle species sighted in sampling areas where replicated samples were taken during spring 1981. Blocks E1 and E2 are the Endangered Species Survey blocks; block RW is the intensely surveyed right whale block within E2.

SPECIES	BLOCK/STRATUM								
	Ex	Ey	Ez	Py	Pz	Qy	E1	E2	RW
B. acutorostrata	0 ±0	34 ±15	50 ±21	27 ±13	16 ±10	56 ±30	0 ±0	0 ±0	0 ±0
B. borealis	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	37 ±22	0 ±0	0 ±0	0 ±0
B. physalus	0 ±0	172 ±143	22 ±15	91 ±63	18 ±18	0 ±0	6 ±7	46 ±39	0 ±0
C. caretta	0 ±0	0 ±0	25 ±9	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
D. coriacea	0 ±0	0 ±0	10 ±5	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
D. delphis	0 ±0	3229 ±3266	4252 ±3045	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
E. glacialis	0 ±0	0 ±0	0 ±0	0 ±0	72 ±68	0 ±0	0 ±0	41 ±37	163 ±195
G. griseus	0 ±0	0 ±0	516 ±322	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
Globicephala spp.	0 ±0	1901 ±1708	779 ±533	151 ±123	0 ±0	208 ±199	0 ±0	0 ±0	0 ±0
Lagenorhynchus spp.	1392 ±1443	0 ±0	413 ±293	8415 ±5217	664 ±610	0 ±0	1146 ±982	763 ±706	614 ±806
M. novaeangliae	0 ±0	0 ±0	0 ±0	11 ±8	0 ±0	0 ±0	14 ±11	19 ±18	8 ±10
P. catodon	0 ±0	14 ±11	16 ±10	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
P. phocoena	0 ±0	196 ±149	0 ±0	468 ±169	308 ±167	72 ±44	313 ±180	0 ±0	0 ±0
Stenella spp.	0 ±0	0 ±0	373 ±172	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
T. truncatus	0 ±0	622 ±357	1457 ±582	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0

DATA SUMMARY FOR PROPOSED LEASE SALE 52

The CETAP cetacean and turtle data as they pertain to Proposed Lease Sale 52 have been summarized in this section.

Of the 30 species of cetaceans and turtles known to occur in or adjacent to the CETAP study area, 18 species of cetaceans and two species of turtles have been reported from within the boundaries of Proposed Lease Sale 52 (Table 32). Among these, ten of the cetacean species occur there commonly, and eight occur there infrequently or rarely. Of the turtles, the loggerhead is common and the leatherback is an infrequent inhabitant. The occurrence within the Proposed Area is seasonal in nature for most, if not all, of these species, and typically is at higher levels in spring and summer. Many of the species, however, are found there year round. But since winter sampling was poorest, so is the understanding of the occurrence and distribution during this season.

There are five endangered species of cetaceans reported from Proposed Lease Sale 52. The fin, sei, and sperm whale occur there most commonly, while the right and humpback whales occur there on an infrequent basis. These data have been plotted by season in Figures 42 a-d. The greater number of sightings in spring and summer is again evident. Feeding or inferred feeding has been reported for each of the five species within the area. Calves or juveniles of the fin and sperm whales have been reported on an infrequent basis.

The leatherback turtle, an endangered species, has been reported on an infrequent basis in the area. The loggerhead turtle, a threatened species, is more common (Figure 43). The occurrence of both species is highest in summer. The area likely represents the warm-season northern extension of the turtles' normal range, for populations which are centered in more southerly waters.

In summary, the southern margin of Georges Bank and Proposed Lease Sale 52 is likely an area of some importance, primarily as a warm-season feeding area, for a number of cetacean and turtle species. Several of these species hold endangered or threatened status.

Table 32 Summary of cetacean and turtle data relevant to proposed Lease Sale 52

Species	Common Name	Occurrence in Proposed 52	Feeding	Calves/Juveniles
Eubalaena glacialis	Right whale	Yes-Infrequent	Yes-Inferred only	No
Megaptera novaeangliae	Humpback whale	Yes-Infrequent	Yes-Inferred only	No
Balaenoptera physalus	Fin whale	Yes-Common	Yes	Yes-Infrequent
Balaenoptera borealis	Sei whale	Yes-Common	Yes	No
Balaenoptera acutorostrata	Minke whale	Yes-Common	Yes-Inferred only	Yes-Infrequent
Balaenoptera musculus	Blue whale	No	No	No
Physeter catodon	Sperm whale	Yes-Common	Yes-Inferred only	Yes-Infrequent
Orcinus orca	Killer whale	No	No	No
Hyperoodon ampullatus	N. Bottlenosed whale	No	No	No
Tursiops truncatus	Bottlenose dolphin	Yes-Common	Yes	Yes
Lagenorhynchus acutus	White-sided dolphin	Yes-Infrequent	Yes-Inferred only	No
Lagenorhynchus albirostris	White-beaked dolphin	Yes-Infrequent	No	No
Globicephala spp.	Pilot whale	Yes-Common	Yes-Inferred only	No
Grampus griseus	Grampus	Yes-Common	Yes	Yes
Delphinus delphis	Saddleback dolphin	Yes-Common	Yes	Yes
Stenella spp. (spotted)	Spotted dolphin	Yes-Infrequent	Yes-Inferred only	No
Stenella coeruleoalba	Striped dolphin	Yes-Common	Yes-Inferred only	Yes
Stenella longirostris	Spinner dolphin	Yes-Infrequent	Yes-Inferred only	Yes-Infrequent
Mesoplodon spp	Beaked whale	Yes-Infrequent	No	Yes-Infrequent
Ziphius cavirostris	Goosebeaked whale	Yes-Infrequent	No	Yes-Infrequent
Delphinapterus leucas	Beluga whale	No	No	No
Pseudorca crassidens	False killer whale	No	No	No
Feresa attenuata	Pygmy killer whale	No	No	No
Kogia spp.	Pygmy / dwarf sperm	No	No	No
Steno bredanensis	Rough-toothed dolphin	No	No	No
Phocoena phocoena	Harbor porpoise	Yes-Common	Yes-Inferred only	Yes
Dermochelys coriacea	Leatherback turtle	Yes-Infrequent	Yes-Inferred only	--
Caretta caretta	Loggerhead turtle	Yes-Common	Yes-Inferred only	--
Chelonia mydas	Green turtle	No	No	No
Lepidochelys kempi	Kemp's ridley turtle	No	No	No

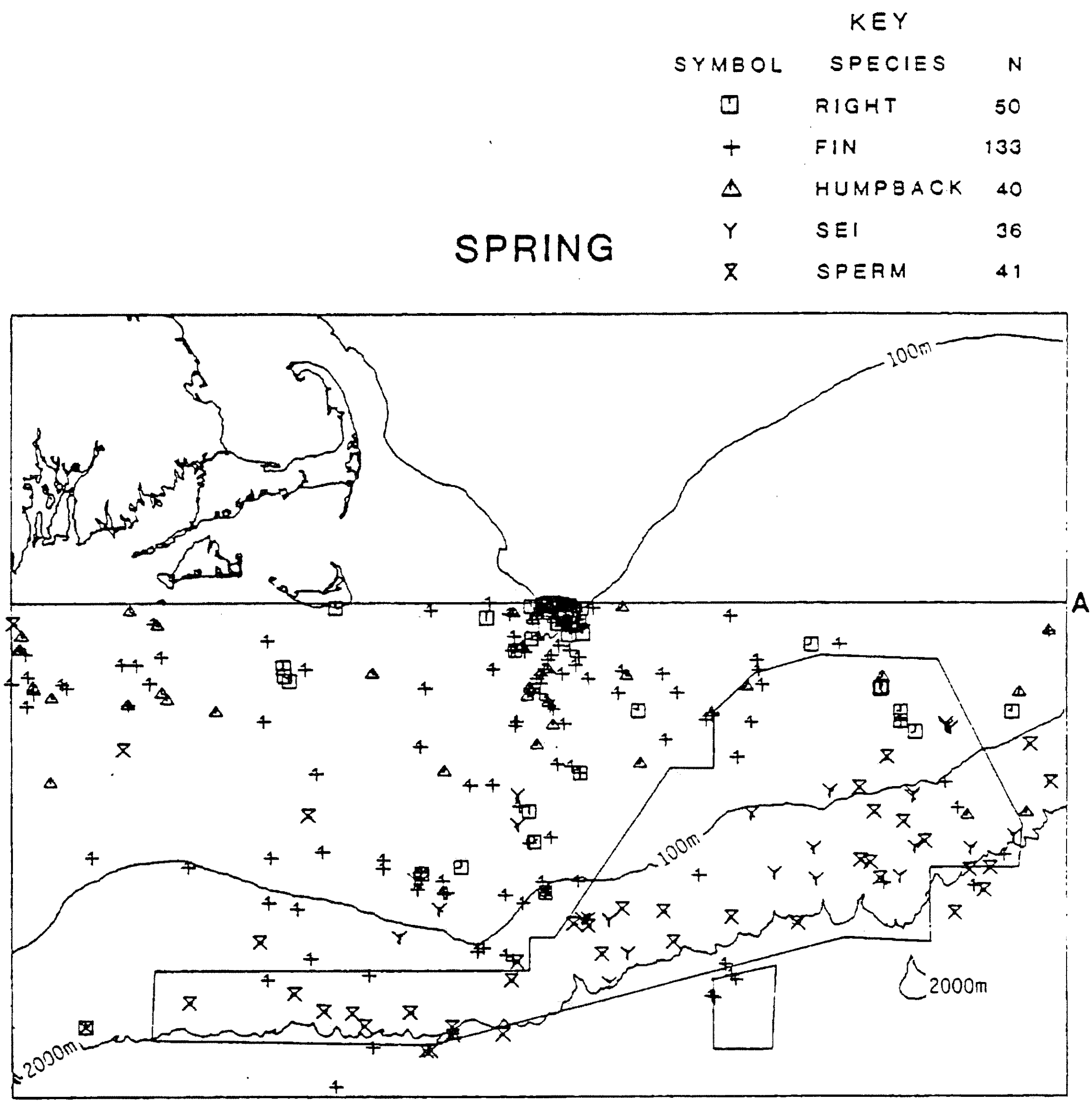

Figure 42a. Spring sightings of endangered species of cetaceans in and near Proposed Lease Sale 52. The data included are from CETAP field studies, 1978-1982, and historical records, 1960-1978, which precede the CETAP study. No sightings were plotted north of the horizontal line labelled "A", as the area is included for geographical reference only. The symbol and number of sightings for each species are given in the key.

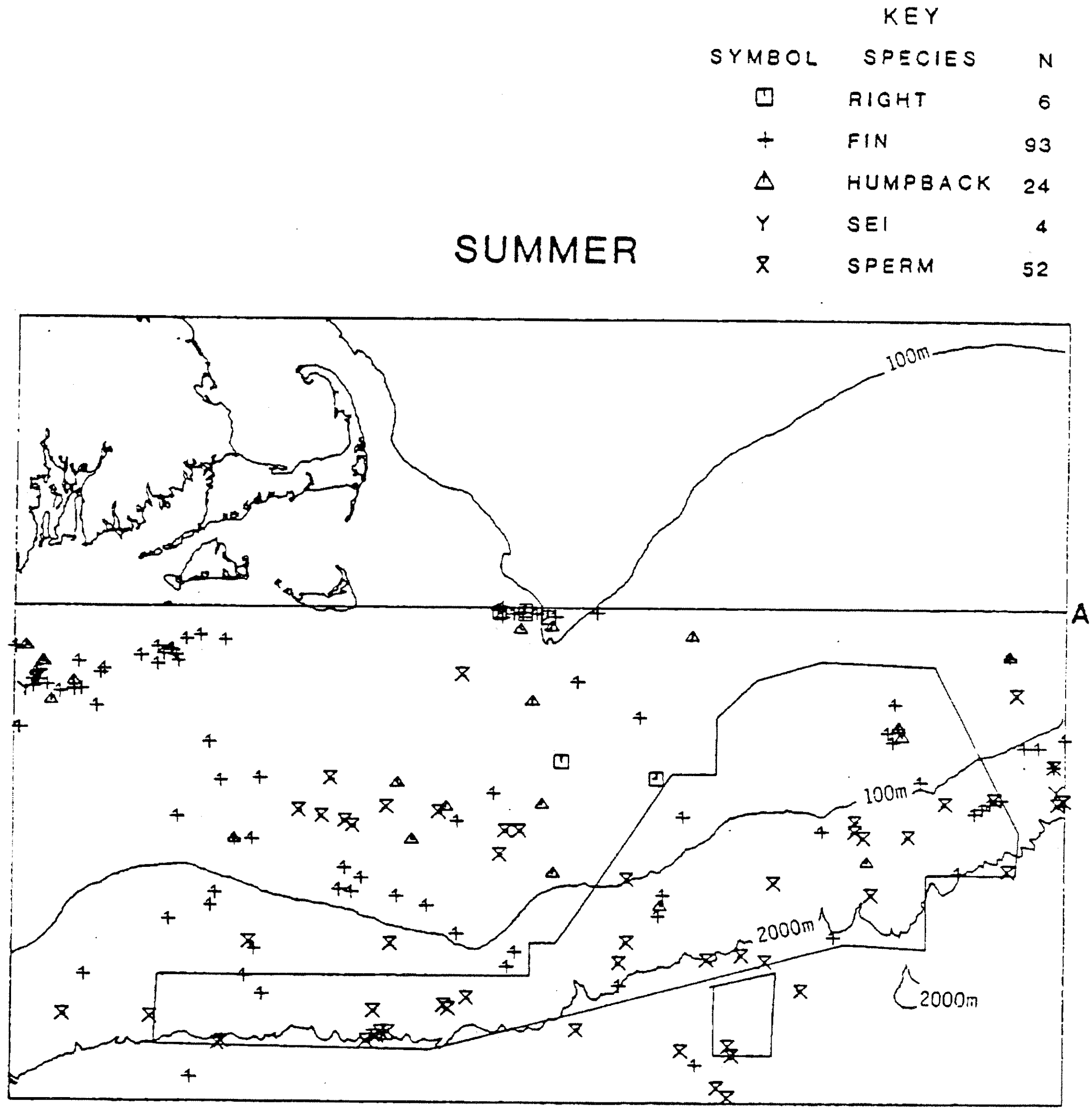

Figure 42b. Summer sightings of endangered species of cetaceans in and near Proposed Lease Sale 52. The data included are from CETAP field studies, 1978-1982, and historical records, 1960-1978, which precede the CETAP study. No sightings were plotted north of the horizontal line labelled "A", as the area is included for geographical reference only. The symbol and number of sightings for each species are given in the key.

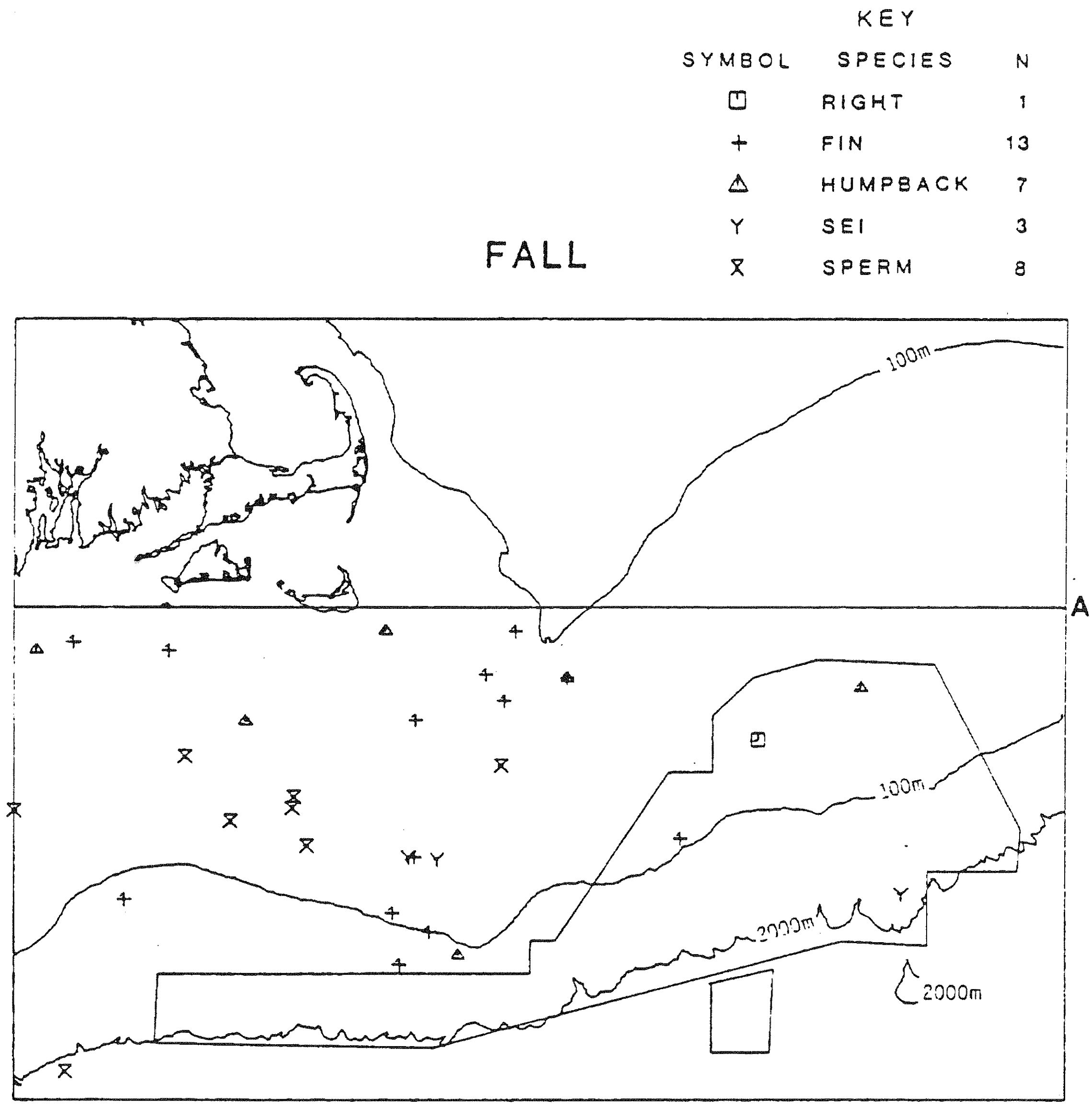

Figure 42c. Fall sightings of endangered species of cetaceans in and near Proposed Lease Sale 52. The data included are from CETAP field studies, 1978-1982, and historical records, 1960-1978, which precede the CETAP study. No sightings were plotted north of the horizontal line labelled "A", as the area is included for geographical reference only. The symbol and number of sightings for each species are given in the key.

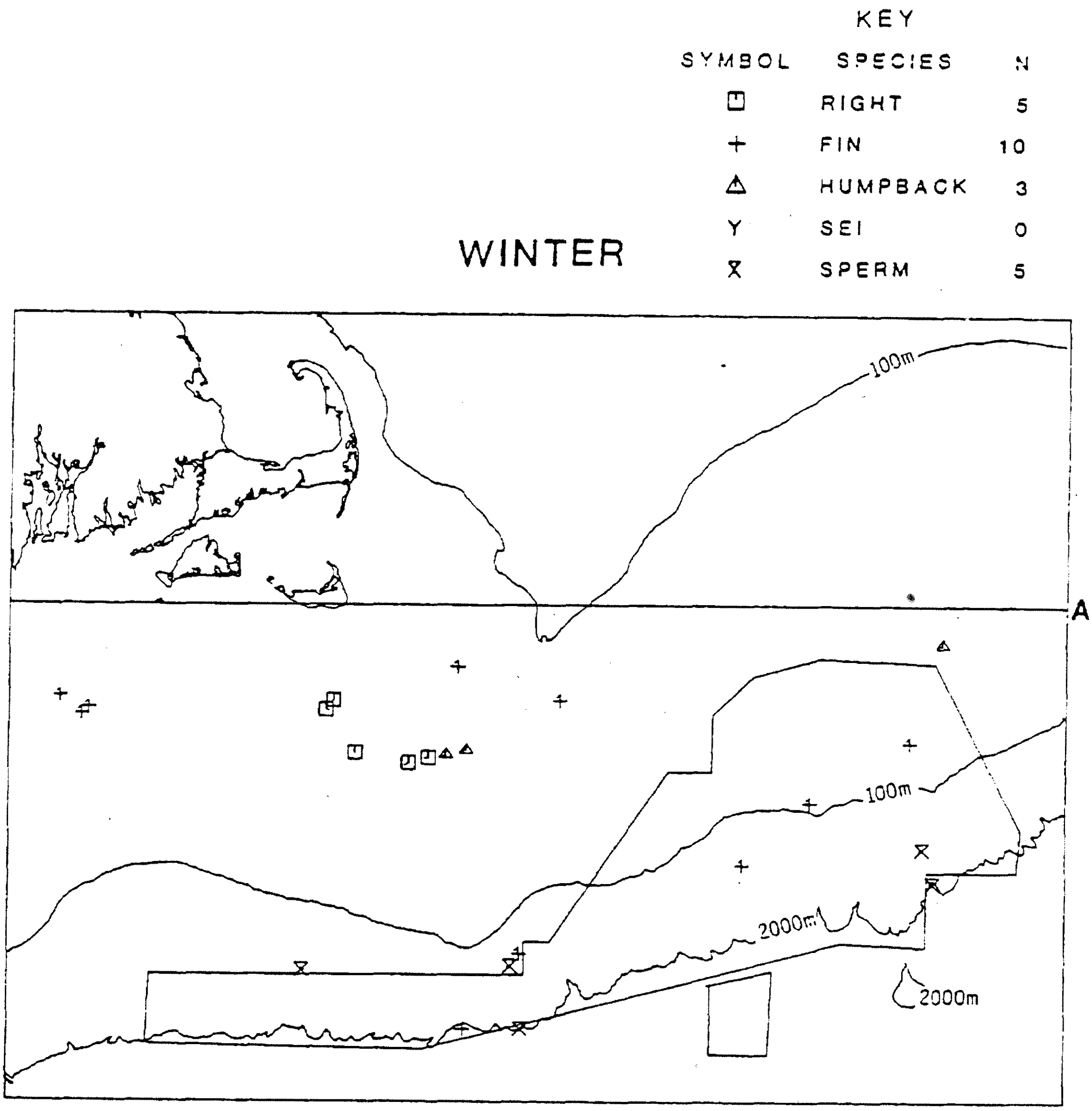

Figure 42d. Winter sightings of endangered species of cetaceans in and near Proposed Lease Sale 52. The data included are from CETAP field studies, 1978-1982, and historical records, 1960-1978, which precede the CETAP study. No sightings were plotted north of the horizontal line labelled "A", as the area is included for geographical reference only. The symbol and number of sightings for each species are given in the key.

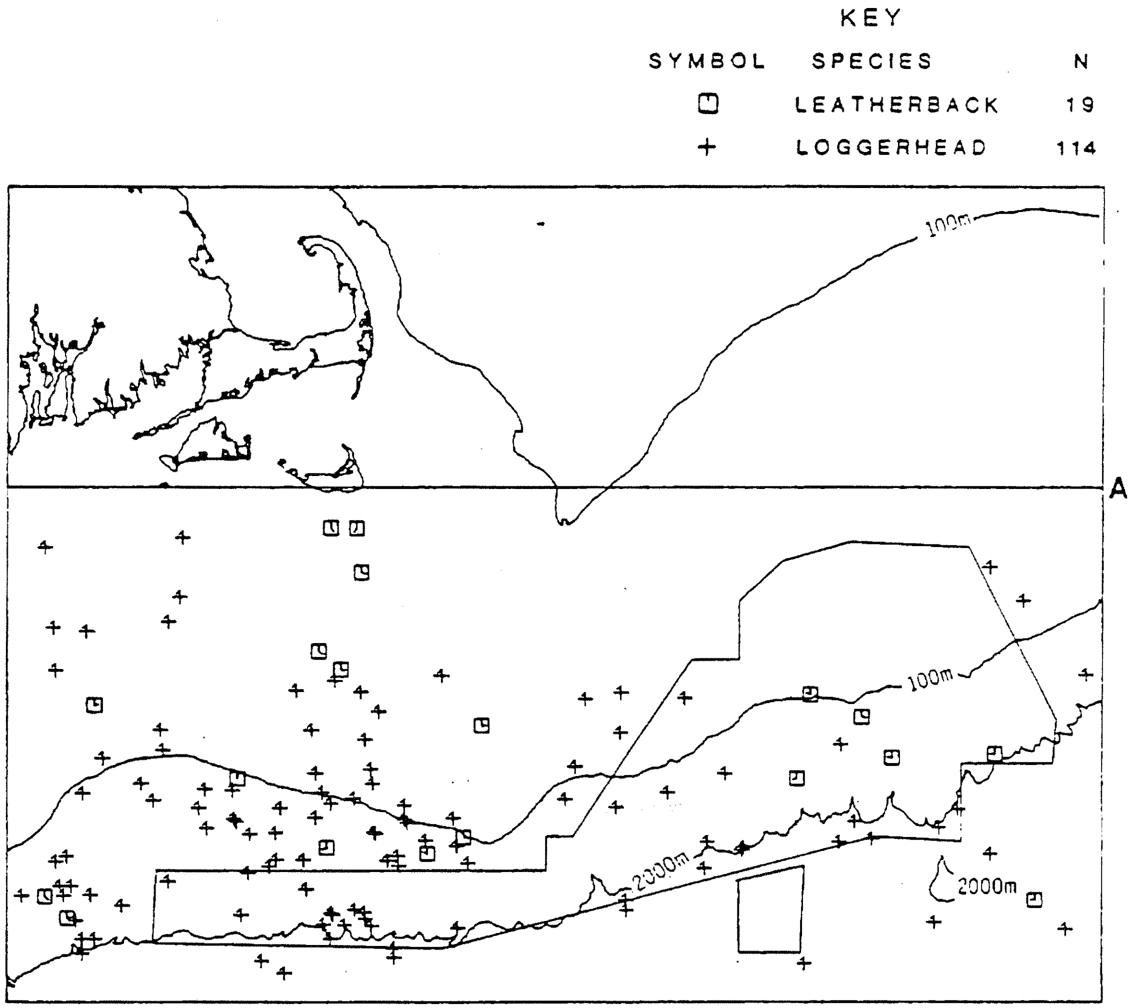

Figure 43. All sightings of leatherback turtles (D. coriacea), endangered species, and loggerhead turtles (C. caretta), threatened species, in and near Proposed Lease Sale 52. The data included are from CETAP field studies, 1978-1982, and historical records, 1960-1978, which precede the CETAP study. No sightings were plotted north of the horizontal line labelled "A", as the area is included for geographical reference only. The symbol and number of sightings for each species are given in the key.

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ANNUAL MODEL OF THE DISTRIBUTION

OF

THE NORTHERN RIGHT WHALE

A Model (Scheme) of the Annual Activities of the Right Whale

The annual activities of the Western North Atlantic right whale should be an organized system. If the population is not to become extinct, growth (assuming optimal feeding), minimal mortality and reproduction must be assured. Once we know the requirements of the system, we can better predict the effect of human influences (e.g. pollution, ship traffic, et cetera).

A model is the development of a scheme of relationships that either attempts to explain a series of sometimes incomplete observations, or relationships that are only theoretically conceived. A model may be qualitative as in the present case, or quantitative. Of course, quantitative models can evolve from qualitative ones.

Unlike formal theories, a model may not be an entirely accurate explanation of reality. As a conceptual scheme, the model hopefully evolves in a series of successive approximations and is modified, eventually attaining the level of a theory--an accurate explanation of reality. A basic first model may even have to be totally discarded as new information becomes available.

Another purpose of a model is to clearly delineate a general pattern rather than to emphasize occasional "noise" or exceptional events in a system. Investigators often attach more importance to aspects of noise in an attempt to demonstrate that a general pattern is not correct. For example, if 2 or 3 right whales were to stay in Cape Cod Bay during the winter, this does not demonstrate that a majority of the population does not migrate southward. One must clearly differentiate between the signal (general pattern) and noise (rare events or occasional exceptions).

A model also gives insight into hypotheses to be tested and sampling schemes to be established. The only danger of such a system is that with an incorrect model, the hypotheses established may also be incorrect, thus the need for continual evaluation of the model.

The proposed model of the annual activities of the western North Atlantic right whale have been divided into six phases (Figure 1), each of which consists of a series of hypotheses with varying levels of supportive evidence. The outline of their annual activities was presented in the CETAP 1979 and 1980 Reports.

THE MODEL

Phase 1 - Winter

Hypotheses - Most right whales inhabit the shallow waters over the continental shelf from Florida to Georgia and possibly up to Cape Hatteras from January into March. A few individuals arrive earlier and stay later. Most animals remain out of sight offshore (out of sight of land) with the exception of mothers and calves, and perhaps pregnant cows or juveniles. Some calving and little or no feeding occurs at this time.

Evidence - Using a variety of data bases, including CETAP's, sightings of right whales off the coast of North Carolina to Florida, occur from November to April, with a clear concentration in January to March (Figures 2, 3a). All sightings were close to shore, however, there was a real bias in sighting effort (Winn et al., 1979). Only a few sighting/strandings have occurred below this area in the Gulf of Mexico (Moore and Clarke, 1963; Schmidley (1972 from Reeves)). Allen (1966) stated that calving took place in the south during January and February. Hunting for the right whale was carried out from North Carolina to Georgia in the winter (Clarke, 1887; Allen, 1916; Stick, 1958). At least half of the near shore sightings in Florida consisted of a cow-calf pair (Moore, 1953; Caldwell, personal communication; Layne, 1965). Pregnant females are isolated from the main group of individuals according to Tomilin (1957). Mating was considered to take place during late winter and early spring (Tomilin, 1957). The birth dates of calves measured in the Bay-of-Fundy could be from February to April (Kraus and Prescott, 1982).

Phase 2 - Late Winter-Spring

Hypotheses - Beginning in early March, right whales start to move northward past Cape Hatteras arriving in the Great South Channel area in late March. Probably little or no feeding occurs during the migration. A few animals travel near the coastline, but a majority may follow the Gulf Stream northward until they move onto the shelf. Inshore animals may be primarily pregnant females, as well as mothers with their calves.

Evidence - Sightings by CETAP in the area of Cape Hatteras to the Great South Channel were primarily made in the late winter and early spring. The inshore sightings do not seem to account for most of the population, contrary to the assertion of Reeves et al. (1978). Our sightings near the 200 m. depth contour in early March, 1980, suggest the animals may have come from deep water (Gulf Stream). No calves were seen. There were several sightings in the Cape Hatteras to Cape Lookout area in the expected migratory time of March and April, including several mother-calf pairs (Region B, Figure 3b). Most historic whaling off Cape Lookout was carried out in winter to early spring (Stick, 1958). A few anomalous sightings were made in June. These sightings could be interpreted as late northward migrants. Perhaps a few whales stay in the area; but this is not supported by any sightings in later months. In region C of Figure 3, there are many offshore sightings spread out over a wide time period. Sightings close to the Virginia and New Jersey coasts have been infrequent in recent years, whereas at least in Delaware Bay they were once commonly hunted (see summary Reeves et al., 1978). Most recent sightings were during the spring migratory period. Right whales have been seen more frequently along Long Island during this period with even occasional summer sightings (Reeves et al., 1978; Katona et al., 1978). It may be that right whales come close to Cape Hatteras and then migrate northward over deep and shallow water. Similarly, southern right whales migrating to the feeding grounds, tend to travel closer to the coastline (Best, 1970).

Phase 3 - Spring

Hypotheses - In March individuals start to appear in 200m waters just opposite the gateway to the Great South Channel running between Cape Cod and the western edge of Georges Bank. One large group stays in the channel area where feeding occurs until late June or early July (see special topic C, this report). Some calving may occur here. Some individuals are seen close to Cape Cod but never appear to stay more than a few days, suggesting that they move quickly northward to the Nova Scotia area.

Evidence - Sightings both inshore and offshore were made in almost all months of the year in region D (Figure 3) with a majority from March to early July. Allen, (1916) on the basis of a summary of sightings from 1605 to 1913, showed that right whales were common off Cape Cod in April and May and absent in summer and early fall, though sporadic sightings existed earlier and later in the season. Most sightings made by Schevill, et al. (1981) from 1955 1980 occurred in March through April off Cape Cod. Three January and one February sighting was made. Whether or not these represent overwintering individuals is unknown. Watkins and Schevill (1980) presented evidence that a few cows gave birth to calves off Cape Cod. Right whales begin to appear in late April the the waters from Cape Cod to the northern Gulf of Maine. These whales are rarely resighted in the same general area for more than a few days, suggesting the northward migration for some individuals takes place without any long stops.

Phase 4 - Early Summer

Hypotheses - Individuals that have spent several months in the Great South Channel now move without any long stops to the Bay-of-Fundy -- Browns Bank area, other individuals having moved there earlier.

Evidence - In region E (Figure 3) mostly offshore sightings were recorded from April to December. These sightings are probably a mixture of spring-fall migrants and particularly in the righthand corner of the block, some residents. Clearly the resightings (right whale, this report) show that individuals move from the Great South Channel area both to the Bay-of-Fundy and Browns Bank. Right whales are observed in the northern areas beginning in July (Region F, Figure 3).

Phase 5 - Summer-Fall

Hypotheses - Most members of the population spend the summer and early to late fall in the Northern Gulf of Maine and southeastern edge of Nova Scotia, primarily in the Bay-of-Fundy area and the Browns Bank to Sable Island area. They feed during this period.

Evidence - Region F (Figure 3) has sightings concentrated in July to September, (Bay of Fundy and southeast coast of Nova Scotia, including Browns Bank). There are many recent sightings in this area in the summer (Neave and Wright, 1968; CETAP; Reeves et al., 1978; Katona, et al., 1978; Kraus and Prescott, 1981, 1982). This area has a high abundnce of Calanus finmarchicus (Bigelow, 1926), (Great South Channel Section, this report), which right whales feed on (Allen, 1916, Coffey, 1977, Watkins and Schevill, 1976). The majority of right whales appear to stay in this area with a few strays going northward (Reeves et al., 1978). Since we saw 46 animals in August, 1980, on Browns Bank, the contention by Mitchell (1975) that the whaler's sightings off Nova Scotia for 1966-1972 represent migrations of only a few individuals may not be the case.

Phase 6 Fall-Early Winter

Hypotheses - From October to early January, the right whales move from Nova Scotia to Cape Cod. The whales do not stop for any protracted time, but appear to be moving steadily southward. Once past Cape Cod, the migrants move offshore, either over the outer continental shelf or in the Gulf Stream. They then appear around Cape Hatteras and move onto the continental shelf off the southeastern states, thus completing the annual cycle.

Evidence - Region E (Figure 3) contains many fall sightings as would be expected. The reason for the small number of sightings in D is not readily apparent unless they move rapidly through the area. Allen (1916) stated that a decrease of sightings off Cape Cod during December indicated a movement to the south. Since southward migrations have not been observed, they must take place offshore (Caldwell and Caldwell, 1974). Best (1970) suggests the southern right whales, when migrating northward from the Antarctic travel offshore and move much faster than in the reverse migration. Similar data is presented by Katona et al. (1978) and Reeves et al. (1981).

DISCUSSION

Generally, the model as presented agrees with historical sightings and catches which indicate that right whales all over the world shift latitudinally during the year. They feed in polar regions in the summer and then calve in warm temperate water in the winter (Townsend, 1935; Tomilin, 1962). The pattern of western Pacific right whales seems to be similar to the pattern suggested for the western North Atlantic (Omura, 1958; Omura et al., 1969, Klumov, 1962). Based on sightings and catch data from the shore net fishery, right whales were found in southern and western Japan from December to March. They then appeared in cold nutrient rich waters off northern Japan in April and May with a movement northward into cold near polar waters in the summer. Sightings were fewer in the fall. Two pregnant female right whales were caught in the eastern Pacific with half grown fetuses, suggesting that they would be born in the winter. The winter habitat of the eastern Pacific right whale was considered to be off Oregon and perhaps northern California with maybe some going to Hawaii (Gilmore, 1956). The latter group would be similar to some whales going to Bermuda in the North Atlantic.

There are very few recent sightings outside the area considered in the model. A couple of strandings have been recorded in the Gulf of Mexico (Moore and Clarke, 1963, Reeves et al., 1978). Payne and McVay saw one individual in Bermuda in 1970 where they were once considered abundant and hunted, and one sighting was recorded both for the Gulf of St. Lawrence (Sears, 1979) and Newfoundland in 1981 (J. Lien, personal communication). Three other Canadian sightings are listed in Reeves and Mead (1978). The evidence to date suggests that only a few scattered individuals stray beyond the area of the model from Nova Scotia to Florida.

The use of historical data to interpret current distribution has certain inherent difficulties. The proposed prime movement of most of the extant right whales from Nova Scotia to the southeastern states with a stopover of many of the individuals in the Great South Channel on the northward migration does not totally agree with the historical data (see summary in Reeves et al., 1981). Once right whales extended more or less continuously northward to Greenland with large winter concentrations in perhaps Chesapeake Bay, Delaware Bay, and perhaps off Cape Cod. It seems reasonable to suggest that today all that remains is the southerly remnant of the once much larger and more widely distributed Western North Atlantic right whale population, the more northerly segment of which inhabited the now empty winter habitats of Chesapeake Bay northward to Cape Cod.

The various phases of activity represent central tendencies. Early arrivals and late arrivals are always present. However, they seem to represent exceptional individuals. The few sightings near Cape Cod in the winter may represent a few animals arriving early (phase 2) or a few leaving late in the southerly movement (phase 6) or they may indeed stay there all winter as suggested in the literature (e.g., Reeves and Mead, 1978). There seems to be a scarcity of sightings in the north from mid-January through February. This could be due to the difficulty of observation in the winter. However, the CETAP surveys indicate no great numbers present in mid-winter. The majority of historical and recent observations suggest a movement to the south in the winter.

Evidence for calving is so far restricted from January to April. If the gestation period is 11 to 12 months as generally believed, then successful mating occurs only during this period. However, many observers (Kraus and Prescott, 1982) talk about mating at other times of the year. It is likely that activities often interpreted as mating are for socialization purposes. Fertilization could be controlled by seasonal ovulation or, as perhaps in the humpback whale, seasonal maturation of sperm.

CONCLUSION

The evidence strongly suggests that the wintering grounds of the western North Atlantic population of right whales is off the Florida-Georgia coast. However, it has yet to be determined how many are in the area and if they are the same animals that are found in the north in the spring, summer and fall. It is likely that a spring migration takes place to the Great South Channel area with some going on to the Bay of Fundy and the southeast Nova Scotia area. Those that spend several months in the Great South Channel go later to the northern grounds staying at least from July to September. Then a rapid migratory procession without significant stops occurs to the southern wintering grounds. The results establish a set of hypotheses with varying degrees of validation. Certainly radio-tagging and individual identification will clarify many of the issues. Behavioral observations are also needed on the wintering grounds in order to learn more about mating and feeding activities.

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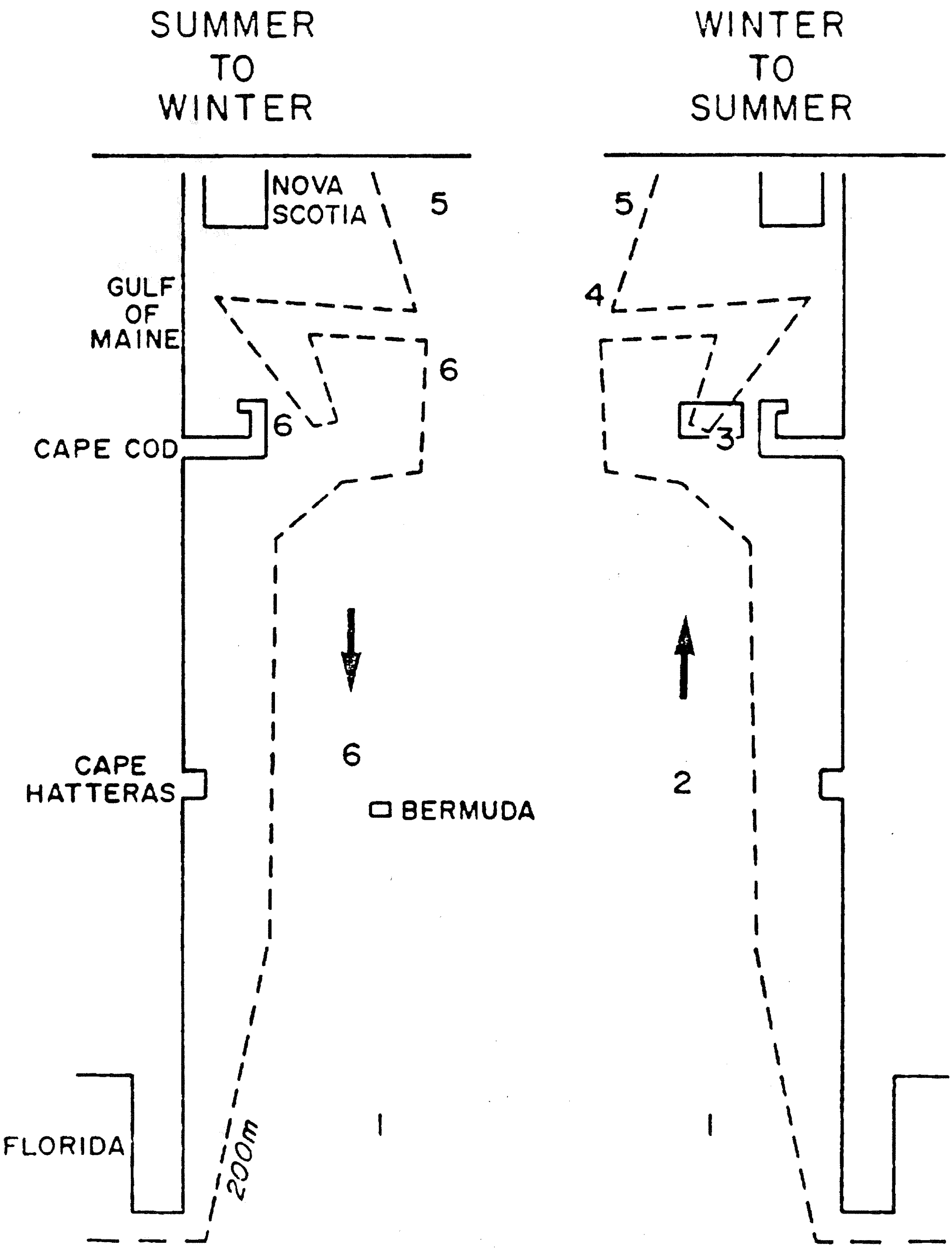

Figure 1. Geographic scheme of six phases of the annual activities of the Western North Atlantic right whale (see text).

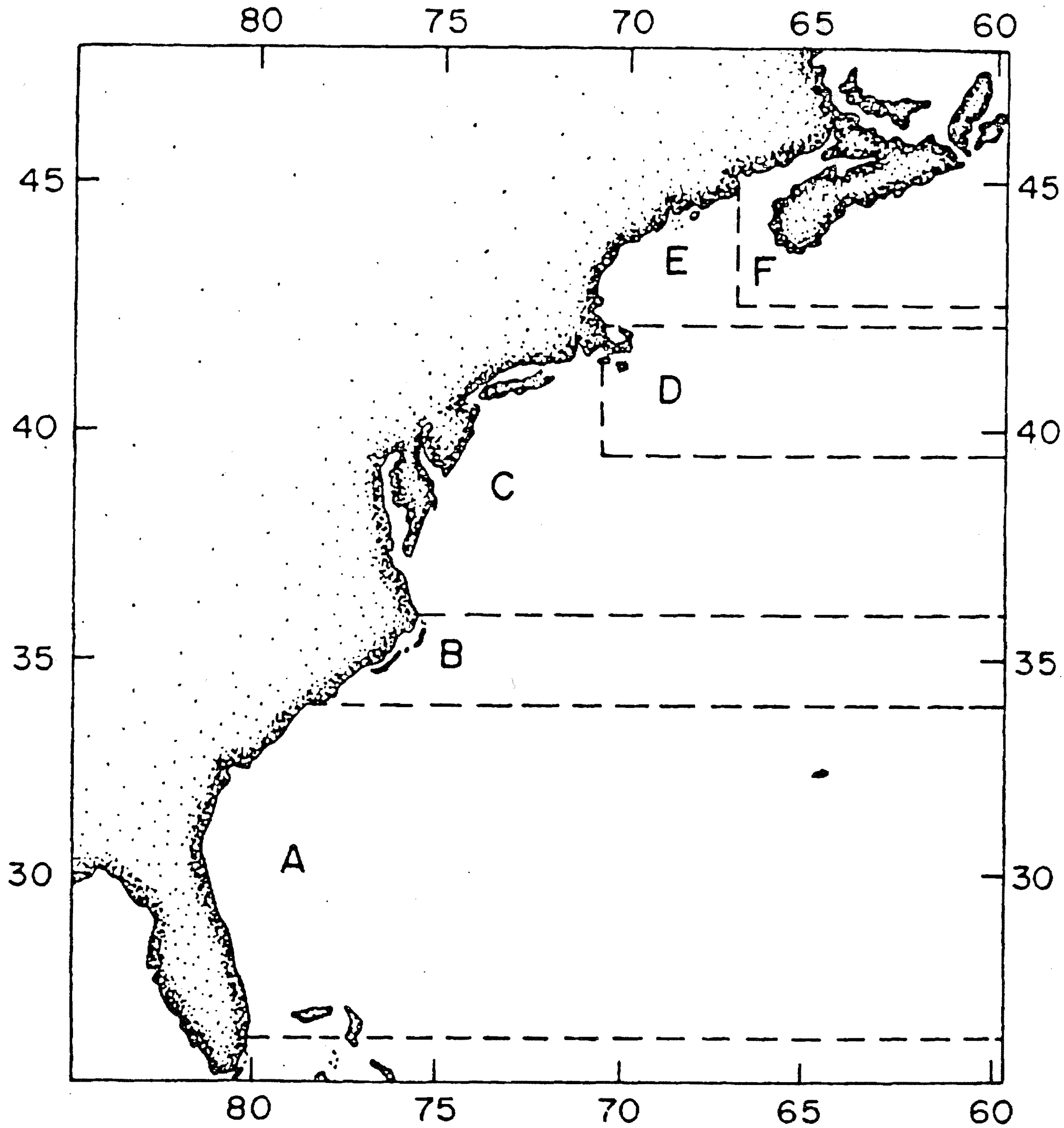

Figure 2. The area along the U.S. Atlantic coast was divided into blocks A to F. Data on sightings by month and inside-outside the 30 mile depth contour were plotted in Figure 3.

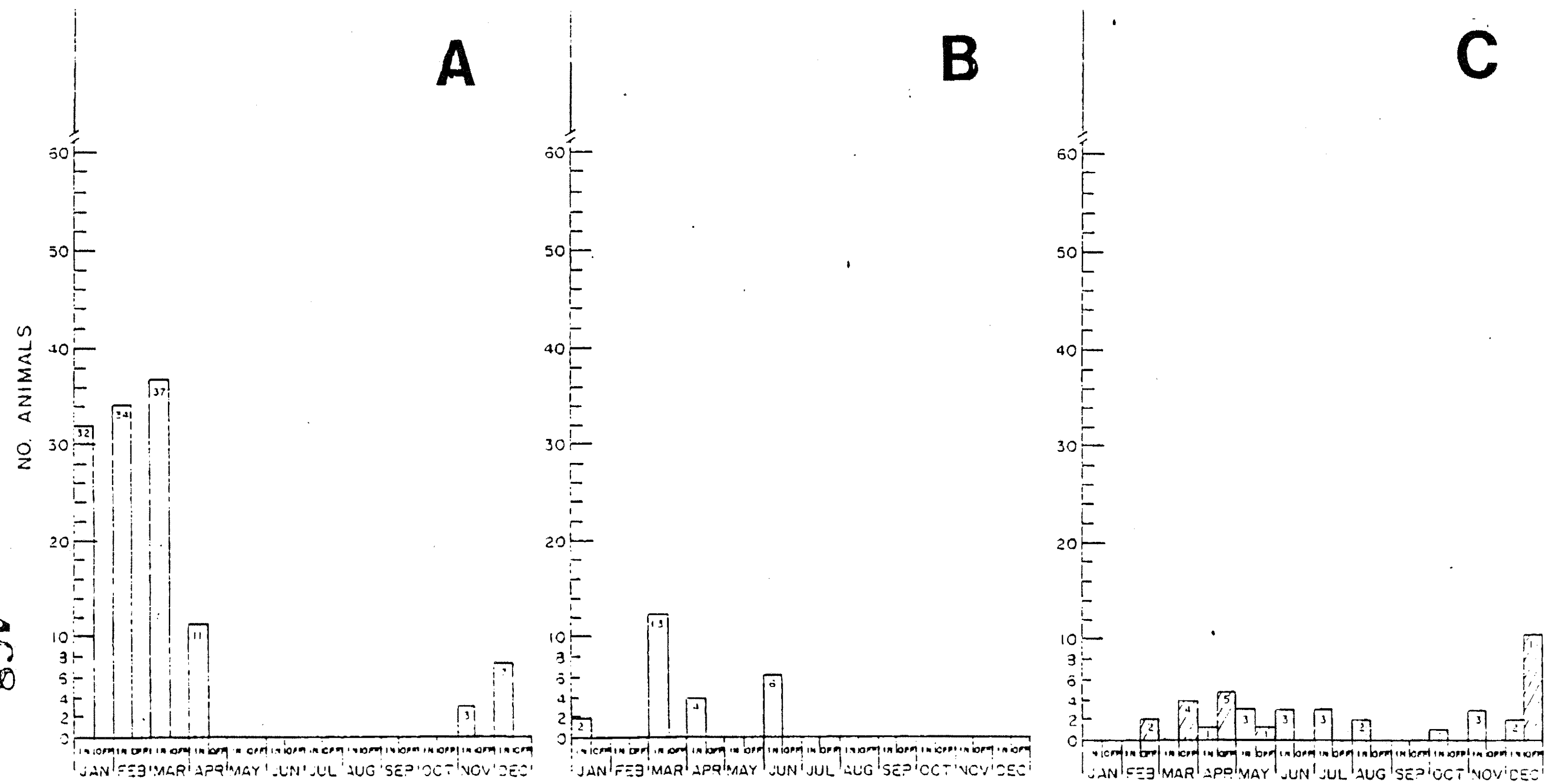

Figure 3. Seasonal and depth distribution of right whales in blocks A to F (see Figure 2). IN = shoreward of the 30 mile depth contour; OFF (hatched blocks) = seaward of the 30 mile depth contour. Data based on SEAN Bulletin; D. Caldwell (pers. comm.); CETAP data; Schevill, Moore, and Watkins (1981); and Sutcliffe and Brodie (1977).

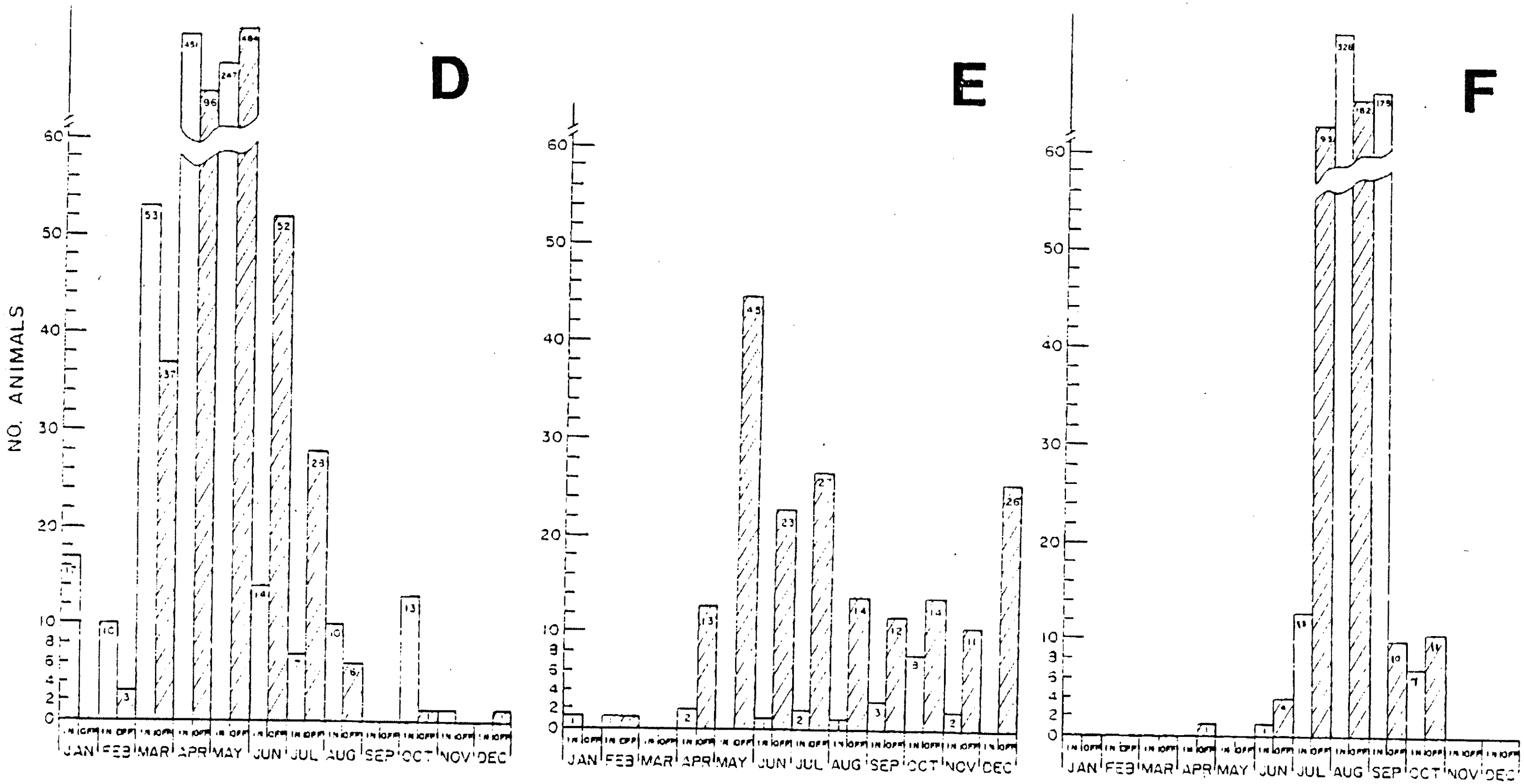

Figure 3 (continued). Seasonal and depth distribution of right whales in blocks A to F (see Figure 2). IN = shoreward of the 30 mile depth contour; OFF (hatched blocks) = seaward of the 30 mile depth contour. Data based on SEAN Bulletin; D. Caldwell (pers. comm.); CETAP data; Schevill, Moore, and Watkins (1981); and Sutcliffe and Brodie (1977).

GENERAL CHARACTERIZATION OF

THE CETAP STUDY AREA

General Characterization of CETAP Study Area

The study area (Figure 1) encompassed the U.S. Outer Continental Shelf (OCS) from Cape Hatteras, NC to Nova Scotia, Canada. The area was divided into 13 manageable survey blocks (E-Q) aligned northeast to southwest along the coastline and stratified by depth. Depth strata were defined based on analysis of spatial distribution of sightings in 1979, and utilized to refine abundance estimates. These strata were; (x) from the shoreline to the 20 fathom isobath, (y) from 20 to 50 fathoms, and (z) from 50 fathoms to a line parallel to, and five miles seaward of, the 1000 fathom isobath. The seaward boundary line of stratum z represented the outermost limit of the study area, which because of asymmetry in the shelf's bathymetry, ran from approximately 35 n.mi. offshore at Cape Hatteras to approximately 216 n.mi. offshore near Cape Cod. In the third survey year (1981), two shelf water survey blocks adjacent to oil lease areas were incorporated into the sampling plan. These areas, R & S, were 50 n.mi. extensions from the outer boundaries of areas Q & G respectively. The total survey area represents 88,759 km^2 (25,878 $n.mi.^2$) and topographically, ranges from the relatively uniform bottom relief in the Mid-Atlantic Bight (from Cape Hatteras to Montauk, Long Island) to the sharp relief in the bathymetry of the Gulf of Maine Georges Bank region. No bays, sounds, or estuaries were surveyed. Complex features such as banks, basins, slopes, and canyons as well as a latitudinal range of nearly 10 degrees from temperate to boreal waters, prevent simple description of the area, however, a clear distinction in both physical and biological factors exists between 1) the Mid-Atlantic Bight, including New York Bight and 2) the Gulf of Maine, including Georges Bank. Further characterization of the study area illustrates these differences.

Physical Oceanographic Features

1. Gulf of Maine - Georges Bank

The Gulf of Maine (GOM) is a semi-enclosed system delimited and partially isolated by Nantucket Shoals and Georges Bank. The deep Northeast Channel in the east and a shallower Great South Channel lead to oceanic waters. The general circulation in the Gulf of Maine is a cyclonic eddy which is well developed in spring but breaks down into two anti-cyclonic gyres in February and March (Bumpus, 1976; Sigaev, 1978). Scotian Shelf water enters from the northeast near Cape Sable and contributes to the formation of the cyclonic eddy . Inflows of water through the Northeast Channel are larger and occur more frequently than outflows and are largely determined by seasonal wind stress (Ramp and Vermersch, 1978). A prominent feature of coastal circulation is upwelling which occurs along the Maine - New Hampshire coasts (Graham, 1970).

The opposite circulation pattern, a well developed anti-cyclonic eddy, exists on Georges Bank (GB) with water originating primarily from Wilkinson Basin and a gradual drift off the southwesterly portion of GB (Hopkins and Garfield, 1981). The residence time of this water is on the order of months (Hopkins and Garfield, 1981) with a clockwise rotation period of approximately 100 days (Bumpus, 1976). The GB eddy begins in May and persists for several months with gradual destruction in winter when short term affects are produced by winds (Sigaev, 1978). This basic seasonal circulation pattern is complicated by strong semidiurnal currents aligned NNW to SSE in clockwise ellipses.

Georges Bank water is well mixed with uniform temperature and salinity year round, compared to the surrounding water masses which experience the typical seasonal stratification cycle (Bumpus, 1976; Hopkins and Garfield, 1981). Thus, unique properties such as continuous nutrient enrichment and subsequent enhancement of biological productivity further identify GB water. The bathymetry of the bank (essentially an elevated plateau) also may contribute to reducing lateral exchange between water masses, and thus preserve the integrity of the overlying water (Bumpus, 1976; Hopkins and Garfield, 1981). Upwelling has been suspected near discontinuities such as the Great South Channel and the northeast peak of GB (D. Mountain, M. Noble, personal communication).

The offshore shelf waters are both warmer and higher in salinity (Fig. 2) than those on GB and in the GOM. The location of thermal fronts between shelf and slope waters is highly variable at the eastern corner of GB and less variable south of Nantucket (Bumpus, 1976).

2. Mid-Atlantic Bight - New York Bight

The general pattern of circulation from Cape Cod to Cape Hatteras is less complex than the GOM/GB system. There is a mean southwesterly flow (0.1 knot) parallel to the coast during all seasons and at all depths (Williams and Godshall, 1977). There appears to be a flow toward the mouths of estuaries in the bottom currents and a compensatory flow seaward of less saline water. Much of the Bight area is dominated by large estuarine systems such as the Hudson, Delaware, and Chesapeake estuaries. The Chesapeake is the largest estuary in North America and as expected, runoff from this and other riverine systems substantially modifies nearshore salinities and nutrient concentrations.

Near the coast there are strong bidirectional semidiurnal tidal currents (2-3 knots), the effect of which rapidly diminishes with distance from shore. Offshore, a southwesterly flow of 0.1 knots (5 cm/s) is found with weak seasonal fluctuations due to runoff and winds. The bottom currents vary from 0.008 to 0.02 knots (Williams and Godshall, 1977) and there appears to be a line of divergence in the general southwesterly flow 1/2 to 3/4 of the way from the shore and the 100 m isobath. Perhaps distributions of sightings in stratum y (20 to 50 fathoms) relate to this feature. In addition, an anticyclonic eddy occasionally developes in the New York Bight region.

At the shelf/slope interface, generally delineated by the 200 m isobath, there exists a strong velocity shear zone. The shear zone creates an elongated cyclonic gyre of slope water between Hatteras and Nantucket and separates the Gulf Stream from the Shelf water.

In winter, the local shelf water is nearly uniform in temperature with a slight increase with depth. In summer, the shelf waters are highly stratified. Because of the latitudinal gradient, the range in mean surface temperature is large. In February at Cape Cod, MA the mean is 3.1°C, at Cape Henry, VA it is 12.8°C. In August, temperature ranges from 20.0 to 25.4°C in the same respective locations (Williams and Godshall, 1977).

3. Effect of the Gulfstream

Although the Gulfstream is generally further offshore than the study area, it does approach Cape Hatteras within 12 to 20 miles before it veers toward the northeast. Also, the Gulfstream has profound effects on the region during infrequent meanders or warm core eddies which pinch off and gradually move southwest (Chamberlin, 1976). In fact, during the CETAP program, one of the largest observed Gulfstream anticyclonic eddies formed in September 1979, off the Northeast Channel, remained east of the channel until February 1980, and then moved south and west along the slope. Its diameter reached 187 km at the surface and it travelled as far as 72°W, east of the Delmarva Peninsula (Fitzgerald and Crist, 1980). According to Chamberlain (1976) there are five (5) major effects of warm core eddies on shelf water: 1) Warming of slope and outer shelf by direct contact which may affect animals' timing of migration or spawning; 2) Injection of warm, saline water as a result of mixing at the inshore boundary which may stress physiological tolerances of fish larvae and eggs; 3) Entrainment of shelf water with subsequent changes in circulation patterns and water properties; 4) Production of upwelling along the continental slope causing nutrient enrichment and affecting biological productivity; 5) Creation of strong currents on the outer shelf and upper slope.

The Gulfstream runs from 2.2 to 4.4 knots (110 - 220 cm/s) off the Mid-Atlantic Bight and produces from 1-4 eddies/year (Williams and Godshall, 1977). In the New York Bight shelf region salinities range from 31-33 o/oo compared to the Gulfstream salinities of 36.5 o/oo (Hanson, 1977). Thus, although the Gulfstream is not typically a consistent feature of the study area, transient effects of long duration are significant.

Biological Features

Although CETAP's study area is physically dynamic, certain regions are characteristic and identifiable. Some distinctions also exist in the area's biological features which may correlate with the distributions and life histories of the resident cetaceans and turtles. Much of the information on the biological characterization of this area was derived from the MARMAP (MARINE RESOURCES, MONITORING, ASSESSMENT AND PREDICTION) program of the National Marine Fisheries Service. The MARMAP program has developed a time-series ecosystems approach ranging from assessments of primary productivity to fisheries interactions (Sherman, 1980) in an area essentially identical to CETAP's (Cape Hatteras to Nova Scotia). Because of the intensity and importance of commercial fishing in the study area, particularly on Georges Bank, most ecological aspects are well studied. However, CETAP represents the first large scale investigation of the cetaceans and turtles in this area which undoubtedly have a significant impact on the ecosystem.

1. Primary Productivity

The most complete survey and review of annual phytoplankton primary productivity (particulate plus dissolved organic carbon) in the euphotic waters indicates that the shelf ecosystem of the western North Atlantic is among the most productive in the world (O'Reilly and Busch, 1982). Utilizing 628 MARMAP stations, O'Reilly and Busch (1982) partitioned the area into 14 sub-areas on the basis of recurrent chlorophyll-a distribution patterns, bathymetry, and hydrography. These 14 sub-areas serve to divide the entire area in a pattern consistent with the regions considered in this paper. Annual primary productivity estimates from the 14 regions ranged from 260 to 470 $gC/m^2/yr$. Figure 2, taken from O'Reilly and Busch (1982), illustrates the productivity estimates from each region. Apparently, high daily rates of phytoplankton production ($1gC/m^2/day$) exist regardless of season. The highest daily measurement exceeded 4 $gC/m^2/day$ in the eutrophic, sewage polluted apex in the New York Bight off the coast of New Jersey but these values were localized and not used in calculating the annual estimate in New Jersey's nearshore waters (370 $gC/m^2/yr$). The chlorophyll-a concentration in the Mid-Atlantic bight is often 5-10 times more concentrated in water more shallow than 20 m compared to water adjacent to the shelf break. On Georges Bank, chlorophyll-a concentrations decrease 5-10 times from the center to the perimeter. The Gulf of Maine contains the lowest average chlorophyll-a concentrations (O'Reilly and Busch, 1982). The most productive area measured is Georges Bank (<60 m) at 470 gC/m^2; least are the mid-shelf off the Delmarva Peninsula (260 $gC/m^2/yr$), the Gulf of Maine (290 gC/m2/yr), mid-shelf off Long Island (280 $gC/m^2/yr$), and the slope water (280 $gC/m^2/yr$); (O'Reilly and Busch, 1982). Sherman et al. (1978) have stated that for the Gulf of Maine, Georges Bank, and the mid-Atlantic Bight, there is a surplus of primary productivity over that amount required for fish production (see also Hill, 1980).

Secondary Productivity

Planktonic assemblages of the Gulf of Maine are primarily boreal, with immigrants from tropical, subtropical, temperate, and arctic regions (Cohen, 1976). Both the diversity and density of zooplankters vary seasonally and spatially within the study area. In 13 MARMAP surveys (180 stations) Sherman and Jones (1980) document that copepods predominate in all areas and seasons with significant differences in their temporal and spatial centers of abundance. Yearly and within year differences also occur in zooplankton abundance estimates, but causal relationships are yet to be determined (Sherman, 1978). Eight copepod species are dominant but high percentage dominance is represented by *Calanus finmarchicus*, *Pseudocalanus minutus* and *Centropages typicus*. In fact, the Gulf of Maine zooplankton assemblage has been characterized as a *Calanus* community (Cohen, 1976). Regardless of seasonal changes, certain regions have developed biological "signatures" with indicator species. Georges Bank water for example, contains the chaetognath *Sagitta elegans* in the well-mixed central portion of the Bank, while two congeners *S. serratodentata* and *S. enflata*, are abundant in the adjacent waters but never on the bank proper. Apparently the well mixed area is sufficiently distinct physically that such biological separation is expected. A similar case is found with *Pseudocalanus* present on the bank and *Calanus* only in the well-stratified waters surrounding it (Clark et al., 1943; Green et al., 1977; Cohen, 1976; Hopkins and Garfield, 1981). In the Gulf of Maine, *Calanus finmarchicus* is found in high abundance throughout most of the year with a maximum of approximately 1000/m3 in late spring to 10/m3 in late autumn (Sherman, 1980).

Sherman and Jones (1980) suggest that changes in copepod densities correlate to hydrographic fronts off the Chesapeake, Hudson, and Delaware estuaries, around Georges Bank, and in the Nantucket Shoals-Rhode Island Sound area. Certainly current patterns, Langmuir convergences, shear zones, and boundaries are known to affect zooplankton concentrations.

Much of the data collected for zooplankton results from studies centered on distributions of larval fish, spawning sites of commercial species, and predator-prey interactions. Not only are copepods the principal food for larval fish, but spawning of cod, haddock, and hake appears to be related temporally to pulses in zooplankton abundance (Sherman and Jones, 1980). In an ichthyoplankton survey on Georges Bank and the Gulf of Maine, Colton and Byron (1977) determined a significant segregation of coastal (boreal) and oceanic (tropical and subtropical) species north and south of the 100m isobath during their December surveys. This divergence corresponds to the shelf/slope thermal front in surface waters along the edge of the continental shelf from November to January (Colton and Byron, 1977). On Georges Bank, the traditional spawning sites for silver and red hake have been along the southern slope of the Bank, whereas herring spawn along the northern edge (Sigaev, 1978) later shifting to the west (Pankratov and Sigaev, 1973). The interaction of the physical dynamics of a heavily fished area and the spatio-temporal occurrence of spawning has a significant impact on commercial fishing. At this level of secondary production, complex interactions occur especially between salps, coelenterates, copepods, chaetognaths, and fish larvae which variously interact in predator-prey relationships and serve as the basis for the next trophic level.

3. Fisheries

The estimated average fish biomass in the New York Bight region is 15 tons/km^2 and 19 tons/km^2 on Georges Bank (Sherman, 1980) despite significant fishing stress in these areas. In the period between 1968 and 1975 fish biomass on the Northeast OCS is estimated to have decreased by approximately 50%. Since then, silver hake and squid stocks have been increasing, but herring and mackeral stocks remain low (Sherman et al., 1981). In general, the study area can be stratified in two major regions on the basis of fish stocks: 1) the Gulf of Maine including Georges Bank; and 2) the Mid-Atlantic Bight.

Colton et al. (1979) have stated that the species composition and abundance of fishes vary markedly. Boreal, non-migrating species dominate the Gulf of Maine and warm water, migratory species prevail in the Mid-Atlantic Bight. Nantucket Shoals appears to separate spawning regions with haddock, pollack and redfish east of the shoals, and bluefish, menhaden, and anchovies westward (Colton et al., 1979).

Obviously, profound effects are likely to occur in the ecosystem when millions of metric tons of fish are removed. From Cape Hatteras to the Gulf of Maine the biomass estimates of herring and mackeral were 3.7 million tons in 1968 to 1.4 million tons in 1975 (Grosslein et al., 1980). However, the evidence to date indicates that, with the exception of significant increases in sand lance (Ammodytes spp.) and squid, the overall composition of the fish community experienced little change. The increase in sand lance abundance, however, has been dramatic, ranging from less than 50% of the total ichthyoplankton community in 1974 to greater than 85% in 1979 (Sherman et al., 1981). Sherman et al. (1981) speculate that the sand lance is a fast-growing, small, and opportunistic species replacing the mid-size predators (herring and mackeral). They compare this to an analogous event in the Antarctic where the smaller minke whales and seals may similarly be replacing blue whales. Sand lance form schools of 500 to tens of thousands and feed primarily on copepods (Meyer et al., 1979).

Thus, sand lances compete for copepods with some mysticete whales and also provide food for others. Since sand lance are plankton feeders, they form very short food webs between ground fish and zooplankton (Grosslein et al., 1980). Whether this density trend will continue or substantially alter the complex interactions at this trophic level is not known.

Regardless of the short term fluctuations in fisheries interactions in CETAP's study area, it is highly likely that continued intensive and selective fishing mortality will manifest ecological perturbations.

Conclusions

Only a brief account has been given of the general characteristics of the study area. The area is a dynamic and heterogeneous system but can be functionally stratified on the basis of depth, bathymetry, current regimes, and biological properties. However, transient and specific events undoubtedly dominate localized areas during our sampling.

The area seems to naturally divide into 1) The Gulf of Maine, 2) Georges Bank and, 3) Mid-Atlantic Bight (including New York Bight). These regions can be further subdivided by depth strata. Differences in primary productivity, current patterns, and the slope/shelf interface provide reasonable support to our depth stratification scheme which was empirically determined from CETAP's previous sighting distributions. The distributions of cetaceans and turtles provide further evidence that the study area is not homogeneous, and that various species maintain "preferred" habitats and migratory patterns.

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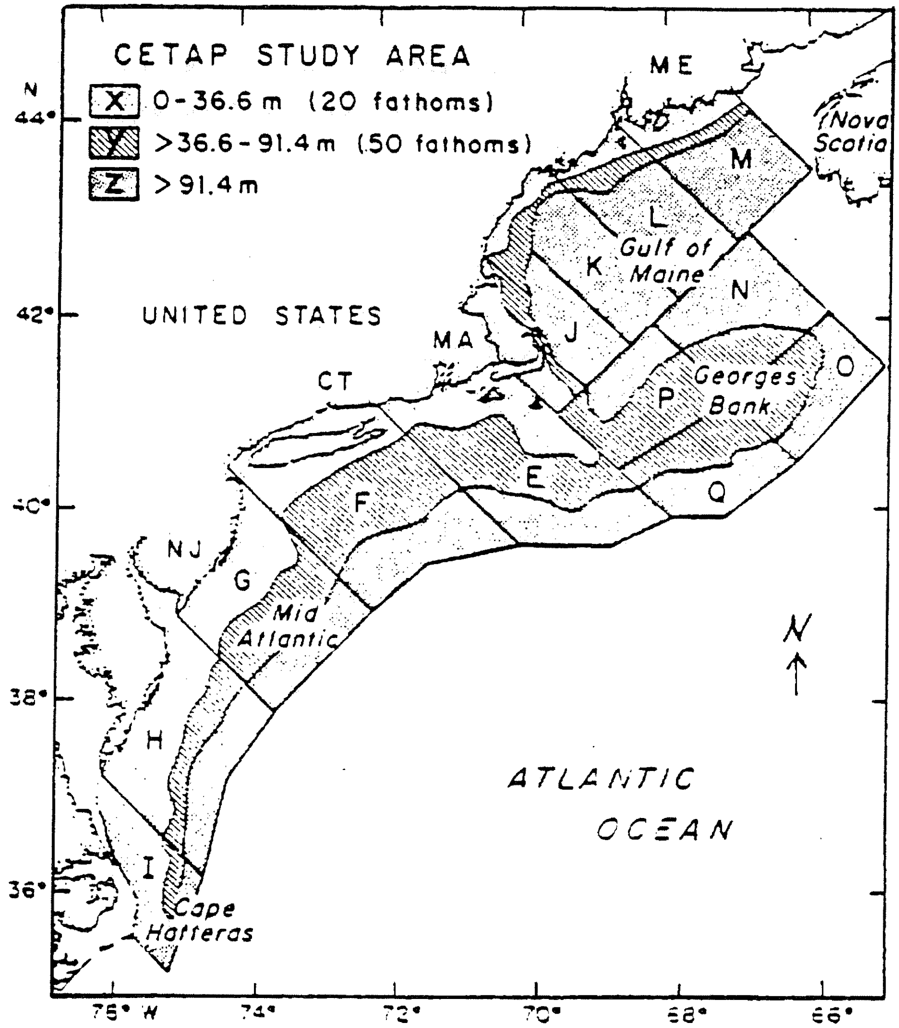

Figure 1. The CETAP study area encompasses 81,154 n.mi.^{2} (278,350 km^2) of the U.S. Outer Continental Shelf between Cape Hatteras, North Carolina, and Nova Scotia, Canada. Additional boundaries are the coastline and a line parallel to, and five nautical miles (9.3 km) seaward of, the surface projection of the 1000 fathom (1830 m) isobath. No bays or sounds are included within the study area. Capital letters are sampling block designators. The sampling area was stratified on the basis of depth zones (strata x, y, and z) representing the nearshore (0-36.6 m (20 fathoms)), shelf (> 36.3-91.4 m (50 fathoms)), and slope (> 91.4 m) regions. The strata are illustrated in three different shadings.

ABUNDANCE AND DISTRIBUTION OF CETACEANS

IN THE GREAT SOUTH CHANNEL AREA

IN RELATION TO PHYSICAL

AND BIOLOGICAL VARIABLES

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INTRODUCTION

Observations of the density distribution of cetaceans in the waters of the US outer continental shelf (OCS) north of Cape Hatteras, NC, indicate that there are a number of cetacean high-use areas in the region (Hain et al., 1981; CETAP 1982). High-use areas are defined to be those portions of the study area where large, high density cetacean aggregations have been observed to persist over a period of weeks to months and/or as an annual event over the three years of sampling conducted by the Cetacean and Turtle Assessment Program (CETAP) at the University of Rhode Island. Among the regions that fall within the definition of high-use is the relatively deep-water channel between Nantucket Shoals and Georges Bank, termed the Great South Channel (Figure 1).

The waters of the Great South Channel have been known to be an area of high-use by cetaceans since the colonization of New England. Clark (1887) reported on the numbers and types of whales found in and near these waters as early as the 1640's. Fisheries for large whales were common along the New England coast until the latter half of the 19th 1Ontury, where these apex predators were known to pursue the vast lmounts of prey available to them.

Data routinely obtained during aircraft-based sampling for cetacean population estimation purposes (Scott and Gilbert, 1982; Scott et al., 1981) and during ship-based sampling for behavioral characterizations (Behavior/Dive Time analysis, Special Topics, this report) was not easily interpreted relative to the physical and biological oceanographic factors influencing cetacean aggregations. In order to investigate these relationships, more specialized sampling was required.

During May 1981, a NASA-sponsored multidisciplinary and multiinstitutional investigation of the phytoplankton dynamics on Nantucket Shoals was conducted (Nantucket Shoals Experiment - Esaias, 1981). Sampling for cetaceans by CETAP was coordinated with that done for the Nantucket Shoals Experiment and the National Marine Fisheries Service, Northeast Fisheries Center (NMFS-NEFC) Marine Resources Monitoring, Assessment and Prediction (MARMAP) sampling (Sherman, 1981). This coordinated and cooperative effort has allowed for the correlative analysis of cetacean distribution in the Great South Channel region relative to other biological and physical oceanographic factors. This paper is a summarization of the results obtained as they pertain to the cetacean component of the ecosystem.

METHODS

Both aircraft- and ship-based sampling were conducted to characterize cetacean density distribution patterns relative to surface and subsurface oceanographic parameters. Three different aircraft were utilized. These included a NASA P-3 four engine turboprop remote sensor aircraft from the Wallops Flight Center, a twin engine Cessna 337-G Skymaster, and a twin engine Beechcraft AT-11. Data relative to cetaceans were also gathered from R/V *Tioga*, a 21 m trawler, and the NOAA R/V *Albatross IV*.

AIRCRAFT SAMPLING

The NASA P-3 was equipped with a number of sensors to characterize surface features in the region in a near synoptic fashion. The sensors on board the aircraft included: 1) Airborne Oceanographic Lidar (AOL) for measurments of fluorescence induced by laser pulses, 2) Microwave Radiometer (both L- and C-Band) for salinity and temperature determination, 3) Multi-Channel Ocean Color Scanner (MOCS) for measurements of ocean color in 20 spectral bands, 4) Precision Radiation Thermometer (PRT-5) for surface temperature measurements, and 5) T-11 Mapping Camera for true color and infrared color images. Descriptions of the aircraft and sensor capabilities may be found in Esaias, (1981). Observations of cetaceans were made and coregistered with the remote sensor data during the following time periods: 7 May, 1145-1527; 8 May, 1423-1730; and 9 May, 0820-1125. Observations were made through a side-looking window at altitudes of 152 and 2286 m and at ground speeds of between 370 - 407 km/hr.

Sampling from the twin engine aircraft was designed to provide estimates of species abundance and density distribution patterns in three areas of interest. The first area (83,935 km^2) was sampled by the AT-11 and included waters from Long Island to mid-Georges Bank (Figure 2). The sampling design employed was depth-stratified and random as described by Scott and Gilbert (1982; also see CETAP, 1982). The entire region was sampled and replicated at the 10% level of coverage during the period of 24 April to 12 June. The second area (24,030 km^2) was sampled by the Skymaster and included waters from south of Nantucket Island to the tip of Cape Cod (Figure 3, blocks E-I and E-II). The sampling design employed was systematic with a single random start for each day of sampling. The entire region was sampled and replicated three times at about the 20% level of coverage during the period of 8 May to 19 May, and at the 10% level of coverage on 9 July, 26 September, and 14 October 1981. The third area (approximately 950 km^2) was sampled by both the AT-11 and Skymaster and included a large multispecies feeding aggregation in the Great

South Channel that was first observed during the P-3 samples (Figure 3, block R). The sampling design was systematic. Fifty to 75% of the surface area was sampled per survey effort. Samples in this area were taken on 14 May, 21 May, 2 June, and 25 July 1981.

Sampling from the Skymaster involved two observers positioned in the aft seats scanning the water surface for cetaceans and other features. Sightings were classified by right angle distance interval with the aid of marks placed on the wing struts (in the fashion of Scott and Winn, 1980; also see Kenney and Scott, in prep) for line transect density and abundance estimation. The co-pilot/navigator recorded position (TDL-711 LORAN-C) and surface temperature (PRT-5) at the beginning and end of transects sampled, at 5 minute intervals during sampling, and when a sighting was made. Sampling from the AT-11 involved rotating 4 observers, 2 at a time, into the forward observation blister. Sightings were classified by right angle distance interval with the aid of marks placed on the observation blister (Kenney and Scott, 1981). Position and surface temperature were recorded as in the Skymaster. A continuous analog of surface temperature was recorded on strip a chart. The radiometer record was digitized and the data contoured (by hand and machine, Calcomp program CONTOUR) to reveal surface temperature regimes in the vicinity of the multispecies aggregation in the Great South Channel.

SHIPBOARD SAMPLING

The primary mission of the R/V Tioga was to obtain baseline behavioral data for endangered whale species (Behavior/Dive Time Analysis, Special Topics, this report). Stations were made at positions where either right (*Eubalaena glacialis*), humpback (*Megaptera novaeangliae*), or fin (*Balaenoptera physalus*) whales were encountered during the period of 10 - 29 May 1981. Stations were also made at other positions when no whales were encountered. However, no systematic method for station positioning was employed with the exception of three transects made on 20 May. These three transects traversed the area in which the multispecies aggregation was found in the Great South Channel. Station positions for the R.V. Tioga are shown in Figure 4.

At each station, samples taken included surface temperature (bucket), surface salinity, surface chlorophyll-a, and surface phytoplankton. Subsurface temperature profiles were obtained with XBT probes and continuous hydroacoustic samples were taken.

Salinity samples were stored in 250 ml glass bottles and analyzed (post-cruise) with a Bissett-Berman Model 6230 Laboratory Salinometer. Salinities were determined to +/- 0.002 ppt.

Chlorophyll-a determinations were made using 25 - 50 ml aliquots of the surface bucket sample. These aliquots were filtered through Gelman glass fiber filters using a Millipore filtration apparatus and under a pressure of 5 mm Hg or less to prevent cell rupture and loss of pigment. During filtration, 2-3 drops of $MgCO_3$ were added to the sample to raise the pH and prevent pigment degradation. Pigments in the frozen filtered samples were extracted by grinding in 85% acetone. Fluorescence was measured before and after acidification with 3 drops of 10% HCl with a Turner Model 1-11 Fluorometer calibrated with chlorophyll extract from spinach leaf.

Phytoplankton samples were preserved in Lugol's solution in 500 ml Nalgene bottles. For analysis, aliquots were settled and organisms counted under magnification to the lowest taxonomic level possible. Sample analysis was conducted at Old Dominion University by Dr. H.G. Marshall.

Subsurface temperature profiles were obtained using Sippican Ocean Systems Corp. T-10 XBT probes. The analog records were digitized in the laboratory at 5 m intervals and contoured.

Hydroacoustic samples were taken with a Raytheon model DE731 analog recorder and a Raytheon model 7193 40-kHz transducer.

Zooplankton samples were collected on board the R.V. _Tioga_ and _Albatross_ IV using 61 cm paired bongo nets (0.333 and 0.555 um mesh) obliquely towed through the water column in the standard MARMAP fashion (Green, 1981). Volume sampled was determined using General Oceanics model S2030 digital flow meters mounted in the mouth of each net. Species densities were determined from aliquots sorted and counted by species.

Determination of zooplankton species assemblages from both qualitatively and quantitatively sorted zooplankton samples was conducted in the fashion of EG&G (1981). Species accounting for >5% of the sample abundance were considered major species. Relative dominance (% of the total sample) was determined within each group of major species for each station and the results used to characterize each assemblage. A 'rough' map of assemblages was drafted and then refined using the samples sorted qualitatively as to relative species abundance. Similarities in the minority species from station to station were used to refine the boundaries between assemblages. Diversity indices for each station were calculated using program DIVPAC16 developed by Drs. H.P. Jeffries and M. Berman, University of Rhode Island.

Nine of the zooplankton samples collected in a 18.5 km swath centered at 41°15'N and running from 69°24'W to 68°32'W were burned in a microbomb calorimeter to determine the available energy in the zooplankton community sampled. The swath described included portions of Nantucket Shoals, the Great South Channel, and Georges Bank. An aliquot of each of the 10% Formalin preserved samples was prepared and combusted in April, 1982. Sample preparation was as in Laurence (1976) and involved first immersing the aliquots in distilled water for 8 hr to remove the Formalin. The samples were then sieved, rewashed, and subsequently dessicated for 24 hr at 90°C. Once dried, triplicates of each sample were pressed into pellets and combusted in a Phillipson Microbomb Calorimeter.

CETACEAN BIOMASS DENSITY DISTRIBUTION

The area defined for the Great South Channel analysis was between 42°00' and 40°30'N and between 70°00' and 68°00'W (Figure 1). For historical perspective of cetacean biomass density distribution in the area the 1979 and 1980 data collected by CETAP were combined, sorted and separated by seasons. For comparison, the spring 1981 data were examined separately. All dedicated aerial survey lines made good from both AT-11 and Skymaster and which fell within the defined area were plotted with a 1-minute grid, breaking the area into 10,800 1' x 1' quadrats. Based upon the average distribution of cetacean sightings relative to right angle sighting distances (Scott and Gilbert, 1982; this report), a relative index of sighting efficiency for each 0.463 km interval out to 1.852 km was calculated; these were: 0-0.463=1.0, 0.463-0.926=0.53, 0.926-1.389=0.275, and 1.389-1.852=0.1. These values were multiplied by 10 and rounded to whole numbers for ease of manipulation, yielding relative effort indices for the survey strips of 10, 5, 3, and 1. An acetate overlay was constructed with a central line and quarter-mile intervals at the same scale as the trackline plots. This overlay was then used to assign a relative effort index to each quadrat on the five plots. The overlay was placed on the plot, aligning the center line with the plotted trackline, and a quadrat was assigned the effort value for every strip where both edges intersected the quadrat. For each quadrat then, this process was repeated for every trackline passing through or nearby, so that the resultant effort value is the sum of values for every line affecting the quadrat.

The same criteria were used to extract all sightings made from dedicated aerial survey lines within the area for each season in the 1979/80 combined data and for spring 1981. The position recorded in the data base for a sighting is actually the position of the aircraft at the time. Since the grid being used was so fine, a more accurate position of the animal(s) sighted was desired to ensure that sightings were assigned correctly to the quadrat which actually contained the sighting. This was accomplished by correcting the sighting position for offset from the trackline trigonometrically using the aircraft heading and the census strip recorded by the field observer. It was assumed for simplicity that sightings occurred in the center of the recorded strip. Once all sightings were assigned to the correct quadrats, all sightings, and also effort values, were assigned the geographic coordinates of the center point of the quadrat.

Average biomass values for individuals of the different cetacean species seen in the area were taken from the literature. These values, and their sources, can be found in Table 1. Biomass values for the various unidentified species categories were calculated by computing a mean value for all those species which could possibly be included in the category. For example, for the category "unidentified balaenopterid, not B. acutorostrata", the biomass values for humpback, fin, and sei whales were averaged; neither blue nor Bryde's whales were considered as likely possibilities. Calculated values for these species categories are also given in Table 1. Biomass values were computed for each sighting by multiplying the number of animals sighted times the average biomass per individual, then for each quadrat by summing the values for all sightings within the quadrat. All biomass values were in metric tons (mT).

Biomass values were then corrected for differential sighting effort by dividing by the effort index for each quadrat. The resultant value was biomass per unit effort (BPUE), in units of metric tons/relative effort unit (mT/REU). The BPUE data were then transformed to bring out detail in the lower ranges. The transformation was the common logarithm of the following quantities: 1) 1000(BPUE) for BPUE > 0.0125, 2) 12.5 for 0.0125 > BPUE > 0, 3) 10 for BPUE = 0 , and 4) 1 for undefined BPUE (cells with no effort). This transformation has the effect of distinguishing sampling zeros (no effort) from real zero values. The minimum value of 12.5 was assigned to force a few very low values to a minimum level to avoid negative values after the log transformation, the transformed minimum value being approximately 1.1.

Finally, the data were plotted in a pseudo three-dimensional format using the PROC G3D program in the SAS/GRAPH computer graphics software package (Council and Helwig, 1981). Latitude and longitude were plotted on the horizontal plane, with the transformed BPUE values on the vertical axis.

CETACEAN ENERGETIC REQUIREMENTS

The energetic requirements of cetaceans can be estimated using the method of Lockyer (1981). A generalized estimate of near-basal metabolic requirements of marine mammals takes the form:

$$M = 110\ W^{0.783}$$

where M is the metabolic requirement (Kcal/day) and W the biomass (Kg). Near-basal metabolism is defined as the cost of slowly swimming and feeding. To calculate the food requirements of a right whale, the resultant quantity is then multiplied by 1.25 to account for an 80% assimilation efficiency (Lockyer, 1981), and then multiplied by 1.5 to account for increased feeding necessary to carry through an assumed 4-month winter period of no feeding. The resultant value is an estimate of right whale near-basal feeding rate (Kcal/day).

The amount of water filtered by a feeding right whale was estimated by multiplying the cross-sectional area of the mouth opening times swimming speed times hours per day spent feeding. Watkins and Schevill (1976) described the anterior aspect of a right whales mouth as "a 1 to 2 meter triangular opening with the lower lip at the bottom." Assuming a triangle with a base and height of 2 m, the cross-sectional area is 2 m^2. A swimming speed of 3 knots was used (Watkins and Schevill, 1976). It was also assumed that right whales were feeding only while submerged, based on behavioral data from the R/V Tioga and on Watkins and Schevill (1976, 1979). The Tioga data indicated that 66% of the average right whale's time was spend submerged between surface activity bouts (Behavior/Dive Time Analysis, Special Topics this report), giving a time spent feeding of 15.84 hr/day.

The minimum zooplankton concentration (kcal/m^3) necessary to sustain a right whale was then estimated by dividing the feeding rate by the filtering rate.

RESULTS

CETACEANS

Historical perspective

Species composition: Table 2 is a listing of all cetacean sightings within the defined Great South Channel area from the beginning of the CETAP data collection effort in October 1978 through the end of 1980. The 1978 sighting data are included with those from 1979. The table includes only sightings identified at least to the generic level, and includes sightings from all CETAP data classes. The cetaceans sighted included 17 different taxa. The most commonly sighted whale species was the fin whale (B. physalus), followed by humpback (M. novaeangliae), right (E. glacialis), and minke (B. acutorostrata) whales. Among the small cetacean species, the most commonly sighted was the Atlantic white-sided dolphin (L. acutus), which was numerically the most common cetacean in the area with a total of over 11,000 individuals seen over the entire period. It was followed in sighting frequency by harbor porpoise (P. phocoena) and pilot whales (Globicephala spp.). Sightings of the other species in Table 2 were infrequent to rare.

Biomass density distribution: Figures 5-8 show the results of the effort-corrected cetacean biomass density distribution analysis. They include all on-census dedicated aerial sightings in the area for the appropriate calendar season during the period now under examination - October 1978 to December 1980. The plots clearly show the pattern of lerial survey coverage during the respective seasons.

Figure 5 shows the spring BPUE distribution pattern. In this and all subsequent plots of this type, approximations of the 50, 100, 150, and 200 m isobaths have been overlaid on the BPUE=0 plane to enable easier visualization of the geographic orientation of the plot and comparison with the two-dimensional map of the area in Figure 1. The figures also show the eastern edges of Cape Cod and Nantucket as stippled areas on the left edge of the plot.

The spring season shows the greatest number of quadrats with positive BPUE values, with many approaching or exceeding 10 mT/REU. The extent of survey coverage was best during this season because of additional special surveys in both 1979 and 1980, however this does not affect the magnitude of the BPUE values, since they have been corrected for level of effort per quadrat. Quadrats with positive BPUE values are found over most of the area, however a dense concentration of high values occurs in an area extending from just east of Cape Cod between the 50 and 150 m isobaths to the northern apex of the Great South Channel.

The BPUE distribution pattern for the summer season is shown in Figure 6. The number of quadrats with positive values is fewer than during the spring months, but the magnitude of the values is increased. Several quadrats have BPUE values nearing or exceeding 100 mT/REU. There is a pronounced concentration of the high values in the area east of Cape Cod between the 50 and 150 m contours, and the western end of Georges Bank is conspicuous due to a nearly total abscence of any cetacean biomass.

Figure 7 depicts the pattern of distribution of cetacean BPUE for fall. The number of positive BPUE values, and their magnitudes, declines notably from summer levels; only four quadrats have values over 10 mT/REU, with one of those nearly reaching 100. The concentration of cetacean biomass east of Cape Cod is still apparent, although to a lesser extent and extending more into waters shallower than 50 m. The only other area with any number of positive BPUE values is in the northeast portion of the area, off the northwest flank of Georges Bank.

Finally, Figure 8 shows the distribution of cetacean biomass per unit effort (BPUE) for the winter season. This figure clearly shows a very low density of cetacean biomass during the winter months, with only a few scattered quadrats with positive BPUE values and only one exceeding a value of 0.1 mT/REU. In fact, all sightings represented on this plot were of small groups of dolphins; no large whales were sighted by dedicated aerial surveys during the winter seasons of 1979 or 1980.

Spring 1981, Nantucket Shoals Experiment

Species composition: Table 3 lists all CETAP sightings of cetaceans which were identified at least to genus in the defined Great South Channel area during the spring of 1981, the season coinciding with the NASA Nantucket Shoals Experiment. A total of 9 different taxa were sighted. The most commonly sighted species, both of large and small cetaceans, were nearly the same as for the 1979/80 period, with the sole exception of the right whale taking over first place as the most frequently encountered large whale, with 122 sightings.

Biomass density distribution: The three-dimensional plot of BPUE vs. position for the spring of 1981 is presented as Figure 9; the format is the same as in Figures 5-8. The number of one-minute quadrats with positive BPUE values appears roughly equivalent to the spring 1979/80 plot (Figure 6), and the relative magnitudes of the values also are approximately the same. The pattern of cetacean biomass density distribution is, however, somewhat different. The main area of high concentration of cetacean biomass in spring 1981 occurs in the northern apex of the Great South Channel, extending somewhat further south into the channel than in spring 1979/80. The portion of the main concentration seen previously in the area just east of Cape Cod is greatly reduced. In addition, there is an increase in cetacean biomass density in the area of the northwest flank of Georges Bank.

Distribution within multi-species aggregations: Figure 10 is a plot of all identified cetacean sightings in the vicinity of the northern apex of the Great South Channel on 20 May 1981. All sightings on that date were made from the R/V *Tioga*, most during the transects which are described elsewhere in this paper.

Only six cetacean species were sighted and identified. With the number of sightings/individuals of each, these were: right (22/73), humpback (10/24), fin (8/9), and minke (6/8) whales; white-sided dolphins (10/736), and harbor porpoise (2/3). The plot shows some degree of separation between the various species. All of the minke whale and harbor porpoise sightings, along with 1 humpback and 2 fin whale sightings, occurred in an area south of the main concentration of sightings. This area crosses over the 100 m isobath on western Georges Bank, and the observers aboard the R.V. Tioga noted the presence of a clearly visible shear or frontal zone at the time. Sightings of the remaining species tended to overlap more, but some separation still can be seen from the plot. For example, although 4 humpback sightings occurred near the same locations as right whale sightings, there was a cluster of 5 other humpback sightings northwest of the main area of right whale sightings.

HYDROGRAPHY

Temperature and salinity data collected during May 1981 by the AT-11 aircraft and the R/V Tioga show an interesting phenomenon in the area of the Great South Channel just north of 41°00'N latitude over the 80-100m contour lines. Figure (11) indicates a definite decrease in sea surface temperature (SST) as one moves southward from 41°20'N (>9.0°C) to 41°07'N (<7.0°C). This gradient or front is greatest between 41°15'N and 41°10'N where the SST drops from 8.7° to 7.2°C. Just to the south of the front and extending approximately 5° east and west of 69°00'W longitude, above the 100-80 m rise or "sill" at the Great South Channel entrance, is a pocket of less than 7.0°C water (Figure 12). The vertical temperature sections constructed from XBT traces shown in this figure suggest an upwelling process to be active in this area.

Transect C appears to run perpendicular to the direction of flow showing the 6°- 8°C isotherms to be relatively depth stable north and west of the 100 m contour line. Transect B reflects the flow of water up into the channel over the "sill" at 80 - 100 m depth. The 6° and 7°C isotherms spread with 7°- 9°C water being forced north and slightly west by rising 6°- 7°C water. Transect A which runs parallel to the flow in this area of the channel, shows the colder water, hitting the "sill" at about 41°15'N, moving upward, and displacing the warmer upper layers upstream. This upwelling of colder denser water at the "sill" is reflected in increasing salinity and sigma-t values as one moves from north to south in the area. Salinity values increase from 32.5 ppt just north of the front to 33.0 ppt in the area of upwelling (Figure 13). Sigma-t values show a similar trend from 25.0 to 25.5 (Figure 14)

PLANKTON

PHYTOPLANKTON

Chlorophyll a

Remote sensor: Figure 15 shows the surface chlorophyll-a data from the Great South Channel area recorded by the AOL aboard the NASA P-3 aircraft. Two east-west transects across the area were flown on 8 May, along latitudes 41°11'N and 41°25'N. The figure includes bathymetric cross-sections along the same transects for reference purposes. Both transects show generally low levels of chlorophyll-a in the surface waters, with all values less than 1 ug/l. Both also show a noticeable drop in chlorophyll-a concentration more or less corresponding to the steeply-sloping western margin of the Great South Channel.

Shipboard data: Seventy-three phytoplankton samples from the R/V *Tioga* cruise of May 1981, 54 of which were collected within the Great South Channel area, were successfully processed and analyzed for chlorophyll-a concentrations. The values measured ranged from 0.053 to 0.499 ug/l, with the great majority falling between 0.100 and 0.350 ug/l. There was no apparent pattern in the distribution of the values which would have enabled plotting of contours. A large number of the samples (39) were obtained in a relatively restricted area at the northern apex of the Great South Channel, approximately bounded by 41°10' and 41°20'N, and 68°50' and 69°10'W. The highest chlorophyll-a concentration measured in this region was 0.364 ug/l. The average value calculated from these 39 samples was 0.206 ug/l, while the average of the 54 samples from the entire Great South Channel area was 0.219 ug/l.

Species densities

Table 4 lists the phytoplankton taxa which were identified and counted from two samples taken aboard the R/V *Tioga* on 20 May. Both samples were obtained along the same transect (Transect A in Figure 12), at positions roughly 18 km apart. Sample T52004-A was taken at position 41°10.4'N, 68°55.2'W. The total count for all species was 474 cells/l. The sample was dominated by dinoflagellates and diatoms, comprising 42.2% and 28.3% respectively of the total number of individuals present. Unidentified flagellates made up another 23.2% of the sample. Sample T52004-C was taken further to the north-northwest along the transect, at position 41°18.7'N, 69°01.9'W. Both the number of identified taxa and total cell count were lower than at the previous station, with the total count being 131 cells/l. Dinoflagellates remained the dominant group, but comprised only 24.4% of the sample, while diatoms accounted for only 6.9%. Two groups not identified in the previous sample, cryptomonads and coccolithophorids, made up 19.8% and 18.3% of the sample, respectively, while blue-greens made up 21.4%. Besides being richer in the number of both taxa and individuals, sample T52004-A contained more large-sized phytoplankters, consequently the phytoplankton biomass represented was significantly greater than in sample T52004-C.

ZOOPLANKTON

Historical Perspective

Data extracted from NOAA's 1978 and 1979 MARMAP (Marine Resources Monitoring, Assessment, and Prediction Program) Surveys indicate May copepod densities of less than $1000/m^3$ for the Great South Channel area (Sherman and Jones, 1980). In April/May 1978, *Calanus finmarchicus* , the dominant species of the zooplankton community in the Gulf of Maine in early spring (Sherman and Jones, 1980) occurred in densities ranging from a high of $100\text{-}500/m^3$ to a low of $1\text{-}10/m^3$. Peak densities occurred north of the 100 m isobath, on the northwestern slope of Georges Bank and in the southern half of the channel. Low densities ($1\text{-}10/m^3$) were found in a small pocket just south of the 100 m contour in the channel. The density in the northern half of the channel and up onto Nantucket Shoals ranged from $10\text{-}100/m^3$. *Pseudocalanus minutus* showed densities of $10\text{-}100/m^3$ throughout the channel and onto Georges Bank. To the west of the 100 m contour line and up onto Nantucket Shoals, the density dropped to $1\text{-}10/m^3$. *Centropages typicus* was absent.

In May 1979, *Calanus* densities reached $100\text{-}500/m^3$ above 41°30'N latitude between 68°00'W and 69°00W longitude. The density in the northern half of the channel was $1\text{-}10/m^3$ and extended to both the east and west. This density increased steadily southward to $100\text{-}500/m^3$ at the southernmost end of the channel. *Pseudocalanus* reached peak densities (100-500/m^3) south of 41°00'N with a small band of 10-100/m^3 extending from Georges Bank across the central portion of the channel (°41°00'N) to Nantucket Shoals. The density along the northwestern edge of Georges Bank and into the mouth of the channel ranged from 1-10/m^3. As in 1978, Centropages was sparse or absent.

Spring 1981

The results of the analysis of the zooplankton samples collected in May 1981 are presented in Figures 16-19 and Table 5. There are five apparently distinct zooplankton assemblages (Figure 16), dominated by different taxa: I.) Metridia lucens, II.) Calanus finmarchicus, III.) Pseudocalanus minutus, IV.) ostracods, and V.) euphausiid and decapod larvae. Of course, the boundaries are not as sharply defined as suggested in the figure; what occurs is a gradual shift in dominance from area to area as indicated by the pie diagrams.

North of the 100 m isobath, the relative abundance of Metridia lucens increases until, by station AL8104-32, well into the Gulf of Maine, it becomes the dominant species, accounting for 58% of the sample. Because of this large percentage, this area has been designated Assemblage I. The densities for this station and other quantitatively sorted samples are listed in Table 5.

The Great South Channel area (north of 41°00'N) is dominated by the Calanus finmarchicus assemblage (II), with a tongue of this assemblage extending southward to at least 41°00'N latitude. The percent composition of C. finmarchicus at the stations within Assemblage II ranges from approximately 45 to 98%, with the highest fractions (90-98%) occurring in an area between 41°15'N,69°10'W and 41°15.6'N,69°05.7'W. Ninety-four percent of the zooplankton sampled at station AL8104-30, located just east of the 100 m contour, was composed of C. finmarchicus, with a species density of 5807.89 animals/m^3 and a total zooplankton density of 6181.63/m^3. This density value is at least three times that of any other quantitatively sorted sample in any assemblage. Stations with the next highest densities of C. finmarchicus are AL8104-31 (1478.88/m^3), T51509 (1402.04/m^3), T51905 (1177.76/m^3). These three stations also produced the next three highest values for total zooplankton densities: 2084.94, 1430.54, and 1468.20/m^3, respectively.

Pseudocalanus minutus is a prominent component of the samples at most of the stations in both Assemblages I and II, making up between 7 and approximately 45% of the samples, with the exception of stations T51509, T51602, and AL8104-30 where it accounts for 3% or less of each sample. The percentage of *P. minutus* increases southward into the Great South Channel area, until it replaces *Calanus* as the dominant species. At none of the stations in Assemblage III, however, did *P. minutus* approach the levels of dominance shown by *C. finmarchicus*. At its highest level of abundance (AL8104-34), *P. minutus* accounted for only 58% of the sample. In the southeastern portion of the assemblage, in the area of Georges Bank, the second most prominent species is *C. finmarchicus*, comprising 20% and 31% of stations AL8104-26 and AL8104-34, respectively.

Moving to the south and west, approaching Nantucket Shoals in water depths of 40 to 60 m, qualitatively sorted samples suggest that ostracods become the dominant species at stations AL8104-14 and AL8104-24 (Assemblage IV).

Station AL8104-22 appears to consist predominantly of euphausid and decapod larvae, possibly indicative of a fifth assemblage. However, as there is only one station, it remains unknown whether this species composition persists toward the north inside the 40 m isobath. For this reason, the boundary between Assemblages III and V is conjectural only, and is shown in Figure 16 by the dashed line.

Graphs of the density, diversity and caloric values for selected stations appear in Figures 17-19. The highest densities, (6181.63/m^3 and 2084.94/m^3) occur on opposite sides of the channel entrance over depths of 120 m and 80 m, respectively (Figure 17). Density decreases dramatically as one moves over the deeper water north of the channel proper. However, with the exception of station T52007, densities are higher over the channel proper than to the east over Georges Bank or to the west over Nantucket Shoals. This density distribution is inversely related to the species diversity at each station, with the exception of T51905 and T52007 (using the equitability index). The lowest diversities occur at AL8104-30, T51509, AL104-26, and AL8104-31 (Figure 18). The highest diversities tend to occur north of the channel entrance and to the west at AL8104-29. The distribution of caloric values per unit volume of water in this same area of the Great South Channel (Figure 19) is directly correlated with the density distribution (Figure 17). The highest values, 0.72 Kcal/m^3 and 0.431 Kcal/m^3 (Table 5), occur on opposite sides of the channel at AL8104-30 and AL8104-31, while the lowest values occur to the east and west over Georges Bank and Nantucket Shoals at AL8104-34 and AL8104-29.

CETACEAN ENERGETIC REQUIERMENTS

Using the value of 22.6 mT for average right whale biomass (Table 1), the feeding rate calculated was 529,250 Kcal/day. This biomass estimate, however, is based on only two individuals (Sergeant, 1969). Including 18 more individuals whose weights are listed in Lockyer (1976) yields a mean biomass of 54.7 mT. Using this value, the calculated feeding rate is 1,057,397 Kcal/day.

With a mouth cross-section of 2 m^2, a speed of 3 knots, and an assumed feeding time of 15.8 hr/day, the filtering rate calculated was 176,014 m^3/day.

Using the feeding rates for both of the biomass values, the calculated values for minimum prey concentrations necessary to sustain near-basal metabolism for a right whale were 3.01 and 6.01 Kcal/m^3.

DISCUSSION

CETACEANS

Species composition

The species composition of the cetacean community of the Great South Channel area did not differ appreciably between the 1979/80 total sighting record and the spring 1981 data (Tables 2 and 3). The former contains 8 more taxa, but most were sighted relatively infrequently, and the 1981 data cover only a single season. During both time periods, white-sided dolphins were the most numerous cetacean, which is true for the northeast U.S. OCS in its entirety (Hain et al., 1981; CETAP, 1982). The most commonly sighted large cetaceans during both time periods were the three endangered baleen whale species: the fin, humpback, and right whales. Differences between the 1979/80 and spring 1981 data, most notably the large number of right whale sightings during the latter period, are most likely due to differential effort. The 1981 data include three occasions when one of the survey aircraft departed at some point from other efforts to fly a very concentrated survey in an area known to contain numbers of right whales (small block labelled 'R' in Figure 3).

Biomass density distribution

The plots of cetacean biomass density distribution (Figures 5-9) generally show a concentration of cetacean biomass in an area from east of Cape Cod into the northern apex of the Great South Channel, perhaps extending along the northwestern edge of Georges Bank, roughly paralleling the 100 m isobath. Concentrations of sightings of various cetacean species have been previously noted in this area (Hain et al., 1981; Kenney et al., 1981; Winn et al., 1981; CETAP, 1982), but any effect of differential distribution of sighting effort could not be satisfactorily determined. The present analysis, by correcting for effort, convincingly demonstrates a real concentration of cetaceans in the Great South Channel area, a phenomenon that appears relatively stable from year to year. Possible reasons for this concentration of whales and dolphins will be discussed later in this paper.

Distribution within multi-species aggregations

Although the Great South Channel area generally supports a relatively large cetacean population during the spring, which we have shown to be concentrated in a specific section of the overall area, it is apparent that there is some degree of segregation between the various species within the overall distribution. One might expect some degree of resource partitioning based upon prey preferences. The right whale is a zooplanktivore, feeding heavily on copepods, while the remainder of the commonly sighted species are primarily piscivores in this area during spring (Gaskin, 1976; Katona et al., 1977; Katona and Richardson, 1974; Nemoto, 1970; Nishiwaki, 1972; Tomilin, 1957). The area containing the main concentration of right whale sightings also was where the zooplankton samples tended to be most dense and most heavily dominated by Calanus finmarchicus. Humpback whales in the area prey heavily upon sand lance (Ammodytes americanus) (Hain et al., 1982; Kenney et al, 1981; Overholtz and Nicolas, 1979), some of whose densest populations are found along the Provincetown Slope east of Cape Cod (Meyer et al., 1979). The cluster of humpback sightings seen in Figure 10 at least tends to occur toward the location of the Provincetown Slope. The remaining four species tend to occur more or less apart from the above mentioned two. Since they are also piscivorous, perhaps they are feeding on other fish species, or on less dense patches of sand lance due to competition from the humpbacks.

HYDROGRAPHY

The isotherm structure in Transects A-C (Figure 12) indicates a definite case of topographically induced upwelling (Sverdrup et al., 1942). Assuming cyclonic flow in the Gulf of Maine (Bigelow, 1927), the southeasterly flow in this area hits the northwestern edge of Georges Bank and the colder deep water, probably Maine Intermediate Water (Hopkins and Garfield, 1979) is forced upward, displacing the warmer upper layers upstream. The result is the surface front due north of a pocket of relatively colder water depicted in Figure 11. Such upwelling may also occur along the slope northwest of the channel entrance. The location and existence of this front most probably varies with seasonal changes in the rate of flow in the Gulf (Cohen, 1976) and with the effects of tidal flow in the channel. However, it definitely appears to be a yearly occurrence in this area as evidenced by similar observations of the surface temperature distribution made in May 1982.

PHYTOPLANKTON

Chlorophyll a

The chlorophyll-a measurements obtained from both the NASA P-3 and the R/V Tioga both indicate quite low concentrations of chlorophyll-a in the surface waters, particularly in the area of the northern apex of the Great South Channel. These data confirm earlier measurements within the same area. Plotted contours of surface chlorophyll in Limeburner et al. (1980), although the data are mostly confined to Nantucket Shoals, show minimum concentrations on the easternmost edge of the Shoals in March 1978, May 1978, and May 1979. The raw data from the R/V Albatross IV from May 1981 (Phinney and Kilpatrick, 1981) also indicate minimum surface chlorophyll values in the general area sampled by the R.V. *Tioga*. From the present analysis, the reason for these low chlorophyll levels in this specific area appears to be grazing by dense zooplankton populations upon the phytoplankton.

Species densities

Although only two of the phytoplankton samples have been analyzed and counted to date, the data obtained from them reinforce the pattern discussed in the section above and elsewhere in this paper. Cohen (1976) reviewed the current knowledge of Gulf of Maine plankton communities, showing the predominant phytoplankton group to be diatoms, followed by dinoflagellates and coccolithophorids. The R.V. *Tioga* samples generally agree with this, however their most interesting characteristics are the differences between the two. Sample T52004-A was higher than T52004-C in number of taxa, total cell count, and richness of larger-sized species and, hence, biomass. The former sample was obtained in an area of scattered minke and fin whale sightings, while the latter came from the area of the major concentration of right whales. The right whales most likely aggregated in response to the very dense copepod populations in this region. Grazing by the copepods would be the main factor in the differences between the two phytoplankton samples. There is some evidence summarized by Marshall and Orr (1972), that *Calanus finmarchicus* selectively filters larger food particles, and may in fact prefer diatoms, so the reduction in cell counts and in numbers of large cells in sample T52004-C correlate well with the high *Calanus* densities in the vicinity of the sample.

ZOOPLANKTON

It is immediately apparent that zooplankton densities and, in particular, copepod densities in May 1981 were much higher in the Great South Channel than indicated by the 1978 and 1979 MARMAP surveys. The density at station AL8104-30 ($6181.63/m^3$) was ten times values recorded previously anywhere in the Gulf of Maine during May. The high densities at stations T51509 and T51905 (Table 5) suggest that densities $>1000/m^3$ are charact isitic of this area of the channel as opposed to the Nantucket Shoals area (AL8104-29) and Georges Bank (Station AL8104-34) where densities were less than $1000/m^3$. In view of this distribution, the high values at AL8104-30, T51905 and T51509 are probably a result of the upwelling described in this report. Such vertical movement of water enriches surface layers with nutrients. Thus, nutrient enrichment induces high phytoplankton production which in turn can support large concentrations of herbivorous copepods, such as Calanus finmarchicus which dominated the sampled in this area (Figure 16). It is also possible that the behavior of the copepods themselves plays a part in the formation of these dense aggregations. Calanus is known to migrate vertically in the water column, remaining at depth during daylight hours (Marshall and Orr, 1972). Numbers of copepods could be horizontally advected into the area with Maine Intermediate Water, which subsequently upwells. The action of the copepods swimming downward in an attempt to maintain a constant depth against a current which continues to bring in more individuals, could provide a potent mechanism for concentrating Calanus.

There is an interesting relationship between the presence of Calanus finmarchicus and the density, diversity, and caloric values at the stations in the Great South Channel area. These three factors all seem to be functions of the relative abundance of C. finmarchicus. The total zooplankton density distribution is directly correlated with that of C. finmarchicus. As is the case with total density, the density of Calanus is inversely related to the diversity distribution (with the exceptions of T51905 and T52007). As this species of copepod is among the larger members of the Gulf of Maine calanoid community, and is known to be of high caloric value (Laurence, 1974), it is not surprising that the caloric value per unit volume of water is also directly related to the relative abundance of C. finmarchicus.

This relationship suggests that the density of _Calanus finmarchicus_ may be used as a meaningful index of caloric value in the Gulf of Maine.

CETACEAN ENERGETIC REQUIREMENTS

Two different values were calculated for the minimum zooplankton concentrations necessary for right whales, using average biomass estimates of 22.6 and 54.7 mT. It is likely that the true value for average right whale biomass for the western North Atlantic population lies somewhere between these two, so they represent good estimates of the extremes of the range. In other respects, the values used in calculating the energetic estimates were extremely conservative. The metabolism estimates account only for near-basal levels, and do not allow for any increased levels of activity. The 3 knot swimming speed used represents the higher speeds observed for feeding right whales by Watkins and Schevill (1976). Furthermore, it is not likely that right whales feed all of the time they are submerged, nor that they feed through the night. It is also highly unlikely that the efficiency of filtering is 100%, as the calculations assume.

Despite the fact that the values of 3.01 - 6.01 $Kcal/m^3$ for the minimum food concentration necessary to sustain a right whale are conservatively low estimates, they represent 4.2 - 8.3 times the highest zooplankton concentration measured during this study (0.72 $Kcal/m^3$), and 7.5 - 15.0 times the average value calculated for the area (0.4 $Kcal/m^3$). Using less conservative values in the estimates, it is possible to get minimum concentrations necessary approaching 20 times the average found. How then can right whales survive. Since our zooplankton samples were oblique tows, the calculated concentrations are averages over the entire water column at that location. It is probable that the zooplankton occurred in discrete patches at one or more depths. Fathometer traces from the R.V. Tioga often showed dense patches of what was assumed to be zooplankton; the trace reproduced in Figure 20 shows a patch near the bottom and less than 10 m in vertical extent just before the 1002 reference mark. Watkins and Schevill (1976) used hydrophone arrays to acoustically locate submerged right whales, and noted individuals returning to the same depth and location repeatedly over a span of several hours. They suggested that this phenomenon was due to the presence of food at that depth. The data shown here would suggest that very dense copepod patches occuring at certain depths in specific locations are the only places where a right whale can find food in high enough concentrations to meet their requirements. Brodie et al. (1978) compared euphausid densities calculated from net samples and from examination of the stomach contents of a fin whale. They estimated that the whale must have been feeding in patches with densities which approximated two orders of magnitude greater than the average concentration.

SUMMARY

The data presented in this report demonstrate that the Great South Channel area is a unique ecosystem. The combination of the current regime and bottom topography result in upwelling which brings nutrient rich, well oxygenated waters toward the surface. This upwelling may provide the mechanism for concentrating large numbers of *Calanus finmarchicus* into dense patches, perhaps assisted by the behavior of the copepods themselves. The multispecies cetacean aggregations observed repeatedly in the area are also in response, albeit indirectly, to the upwelling regime. Right whales are most likely present due to the dense food patches available to them. We have shown both that right whales require patches above a certain minimum density, and that *Calanus* concentrations in portions of the area are the highest measured in the Gulf of Maine. Even if right whales could find food concentration above the minimum required in other locations, optimal foraging theory predicts that an animal should select the patches providing the highest rate of energetic return (Krebs, 1978). For the other cetacean species, it appears that the sand lance (*Ammodytes americanus*) is the major prey species. Sand lances feed primarily on copepods (Meyer et al., 1979; Covill, 1959; Reay, 1970; Scott, 1973; Sekiguchi, 1977), so that the Great South Channel area contains abundant food. In addition, since sand lances burrow into the bottom, they require habitats with well oxygenated sediment pore waters (Reay, 1970). The combination of highly-oxygenated water and dense copepod concentrations produced by the upwelling regime should provide optimal *Ammodytes* habitat. Meyer et al. (1979) found some of the densest populations of sand lance along the Provincetown Slope east of Cape Cod. The large numbers of cetaceans other than right whales observed in the Great South Channel area most likely aggregate in response to the localized concentrtions of *Ammodytes*.

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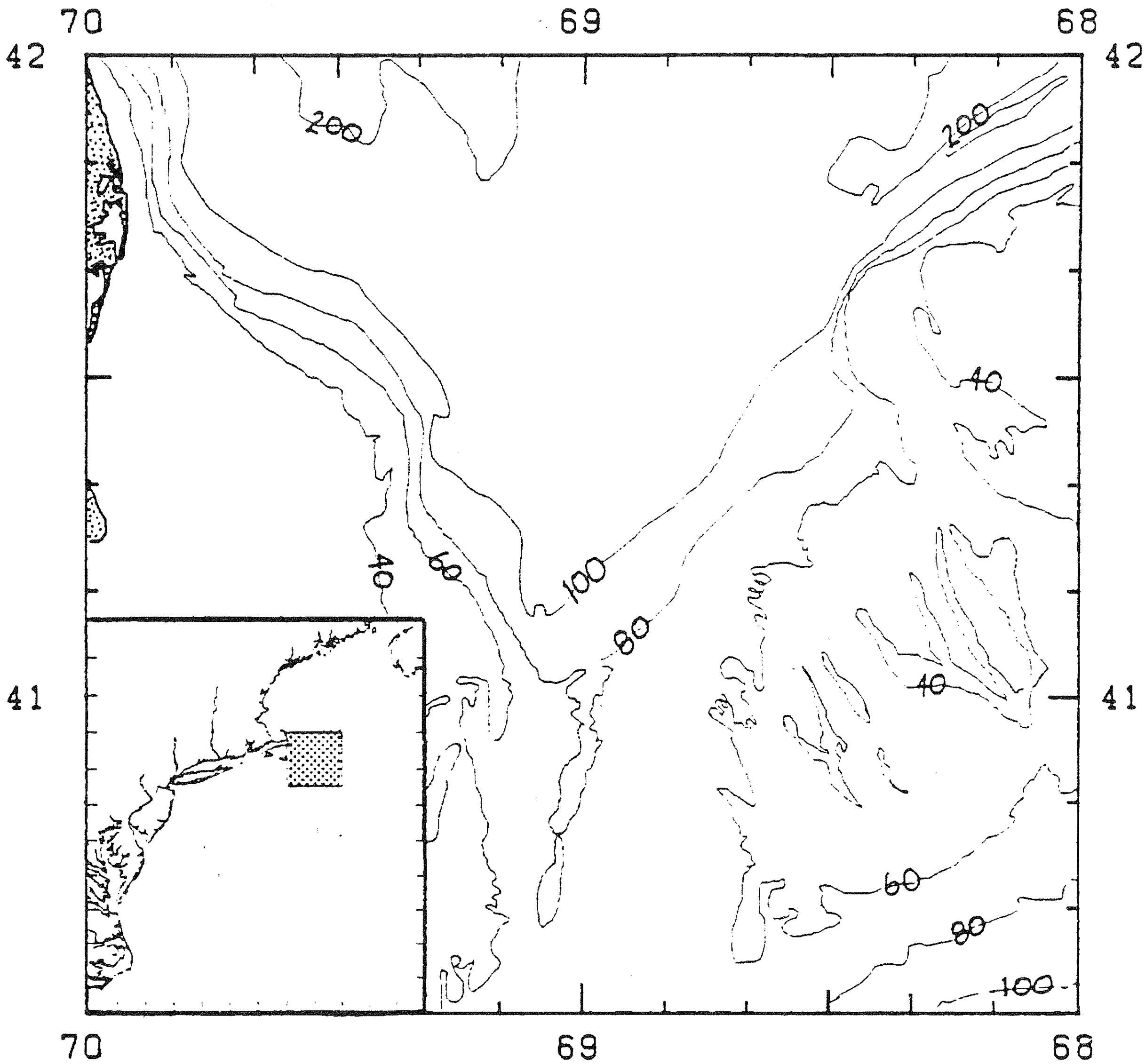

Figure 1. Great South Channel study area. Shaded block on inset shows the location of the area relative to the U.S. northeast coast. Depth contours in meters.

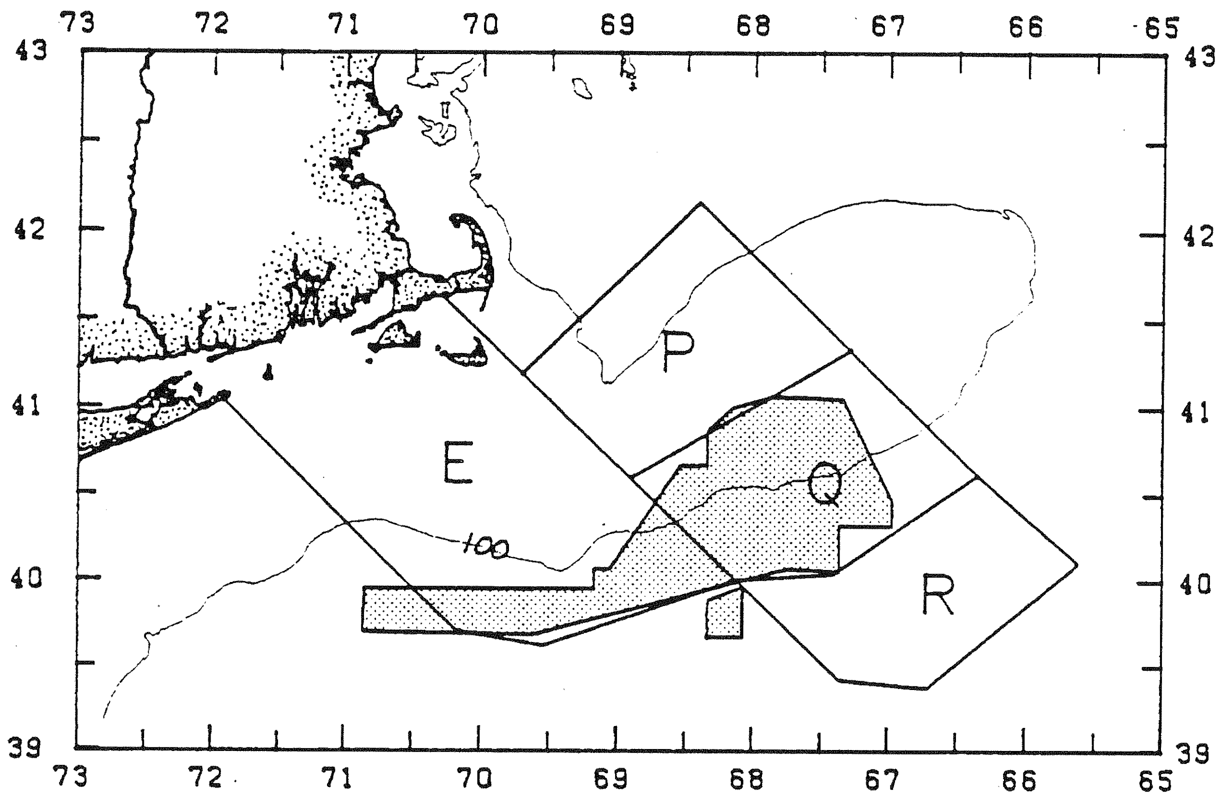

Figure 2. CETAP main aerial survey blocks E, P, Q, and R which were sampled by the AT-11 during spring 1981. Shaded area shows approximate extent of BLM proposed Lease Sale Area 52. The 100 meter isobath is shown.

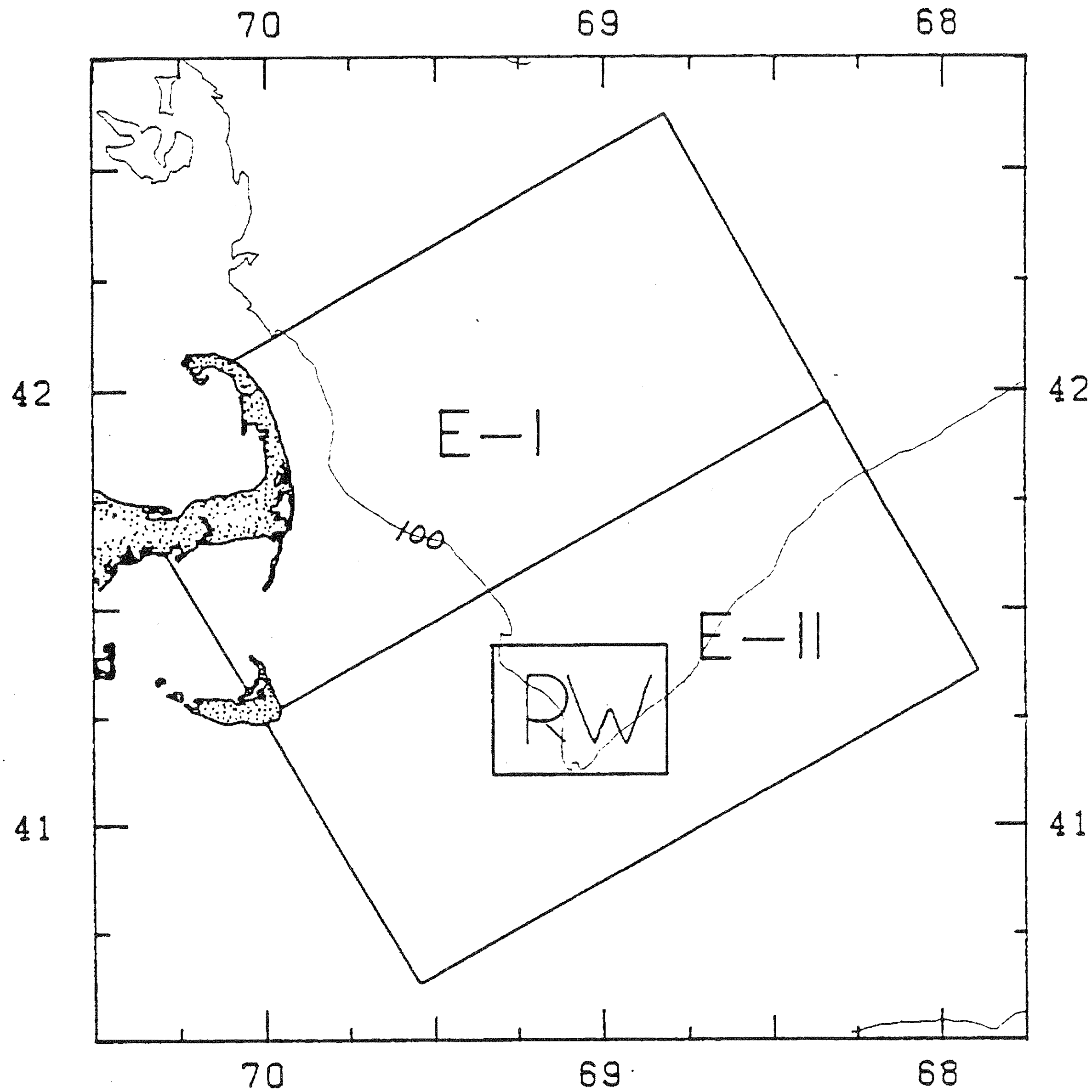

Figure 3. CETAP 1981 endangered species survey blocks. Blocks E-I and E-II were sampled by the Skymaster, block RW by both the Skymaster and the AT-11. The 100 meter isobath is shown.

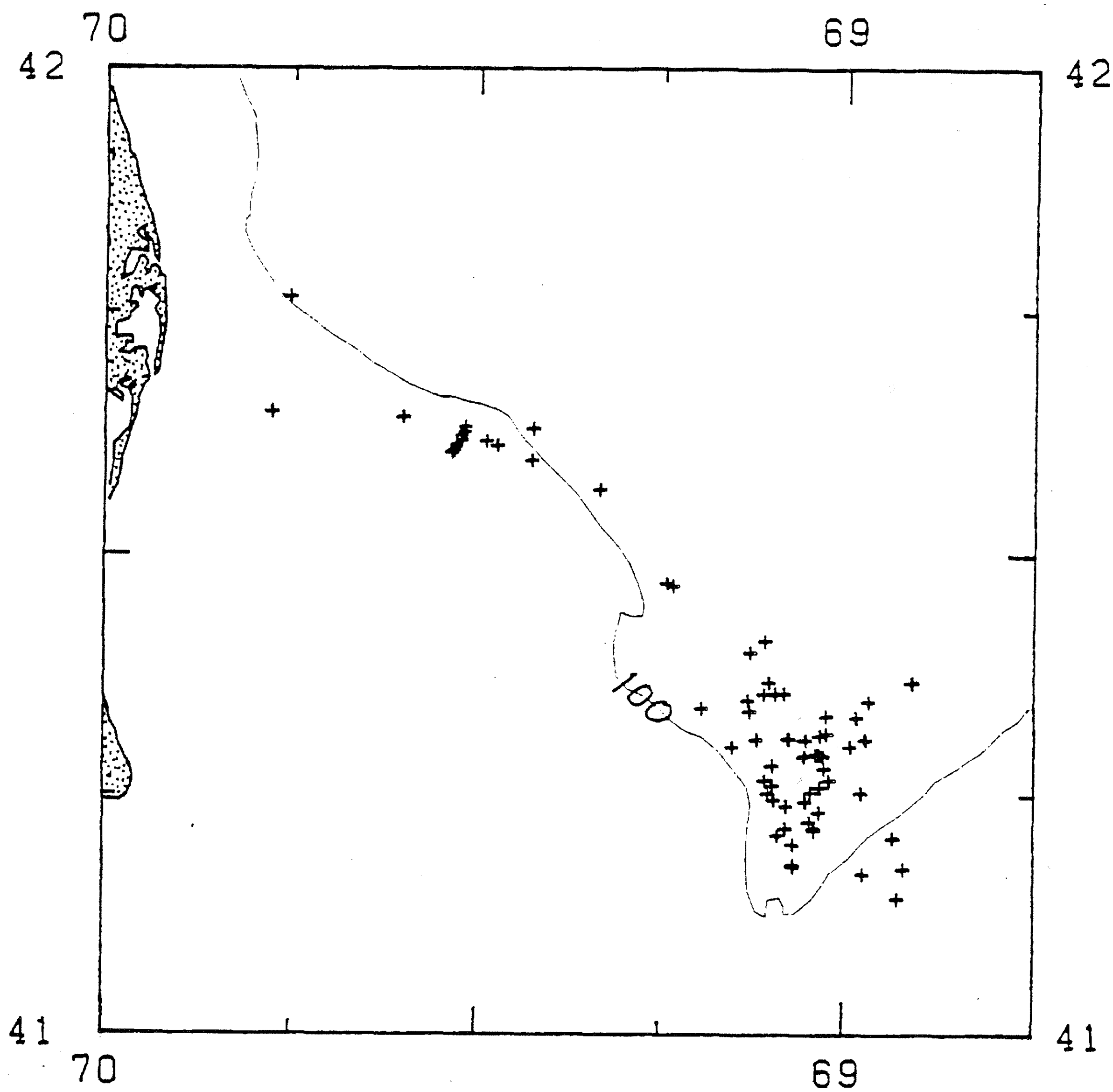

Figure 4. R/V Tioga stations in the Great South Channel area, May 1981. The 100 meter isobath is shown.

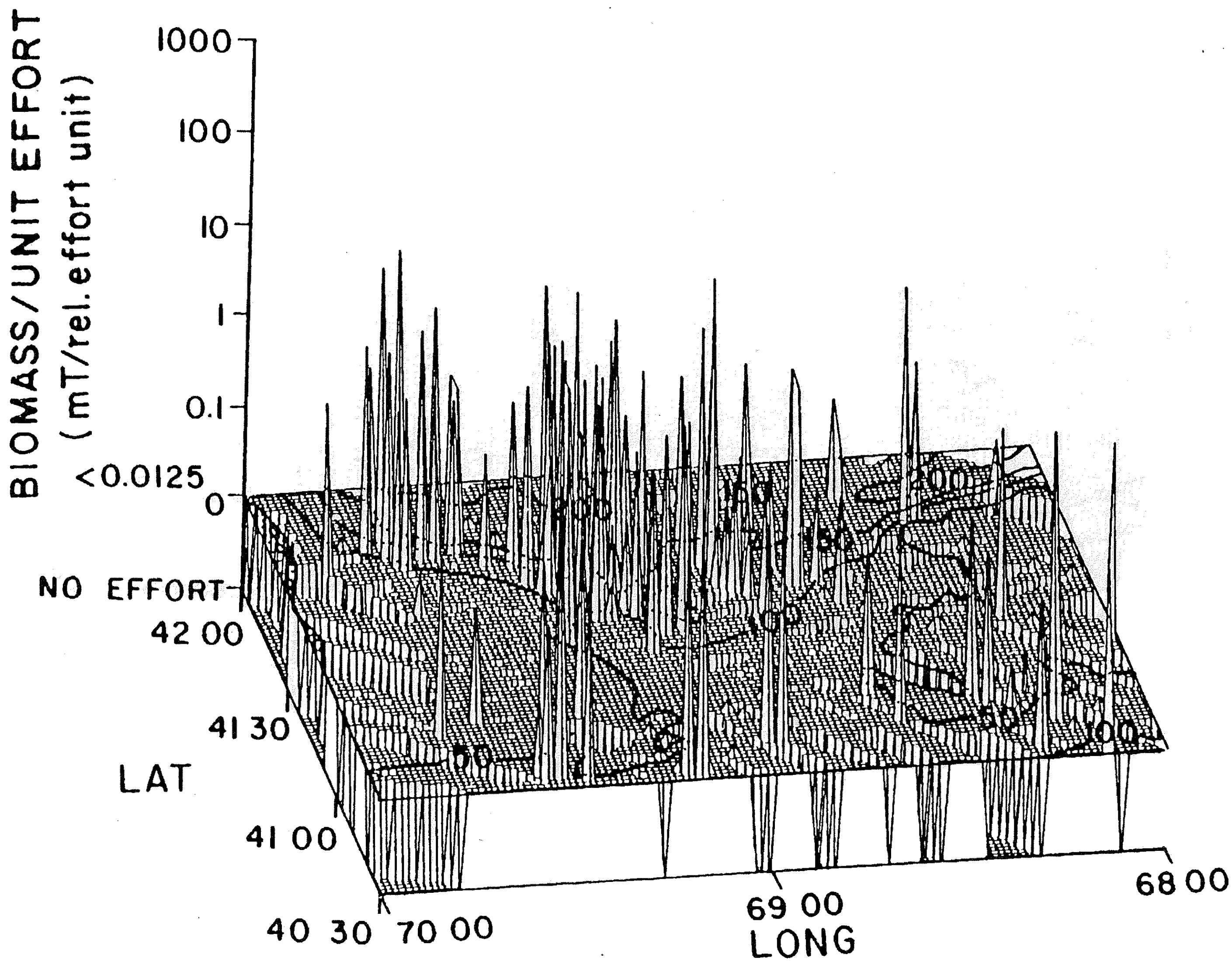

Figure 5. Plot of cetacean biomass sighted per unit of sighting effort by one-minute latitude/longitude quadrat in the Great South Channel area for spring 1979 and 1980. Isobaths in meters.

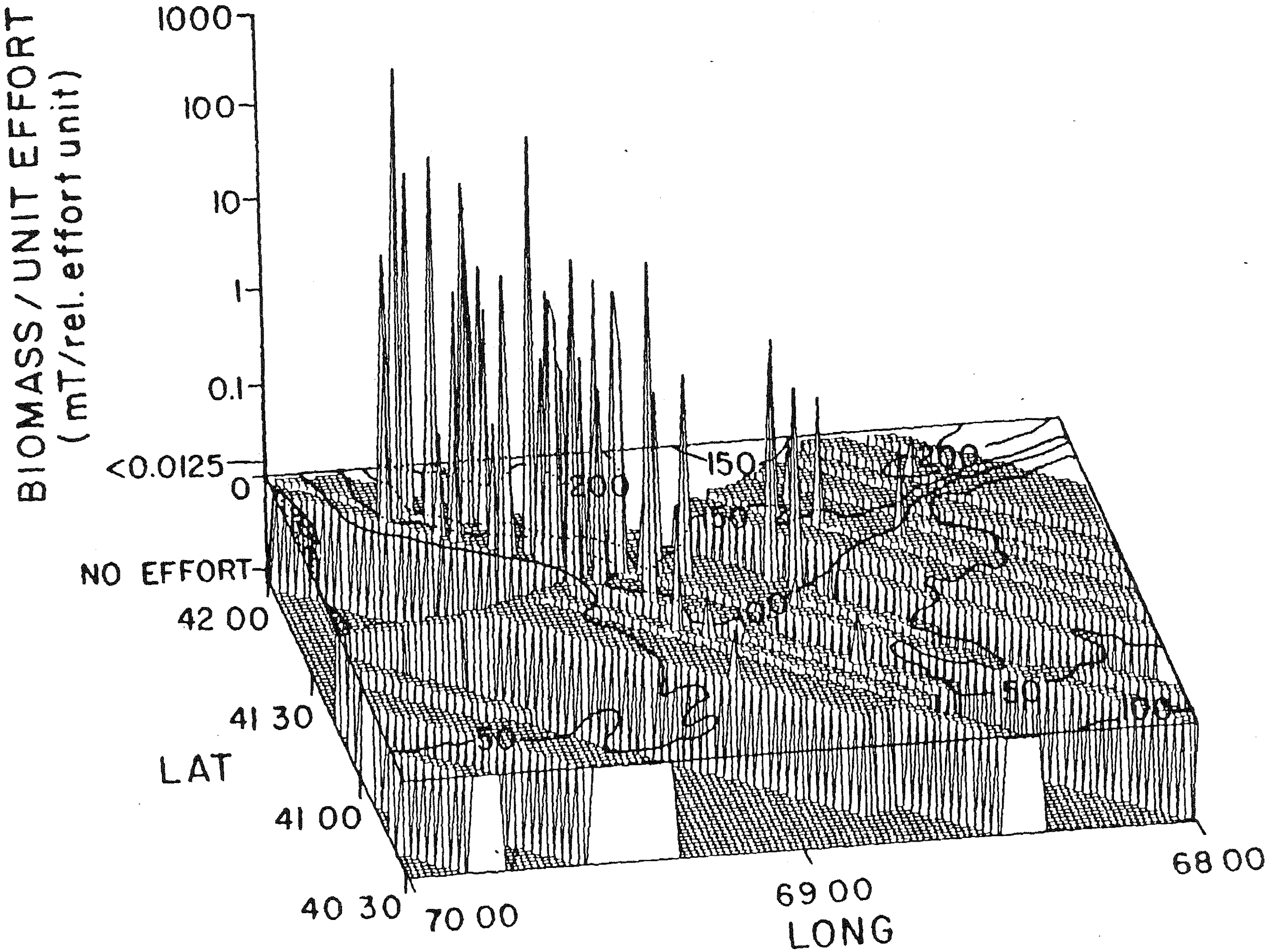

Figure 6. Plot of cetacean biomass sighted per unit of sighting effort by one-minute latitude/longitude quadrat in the Great South Channel area for summ 1979 and 1980. Isobaths in meters.

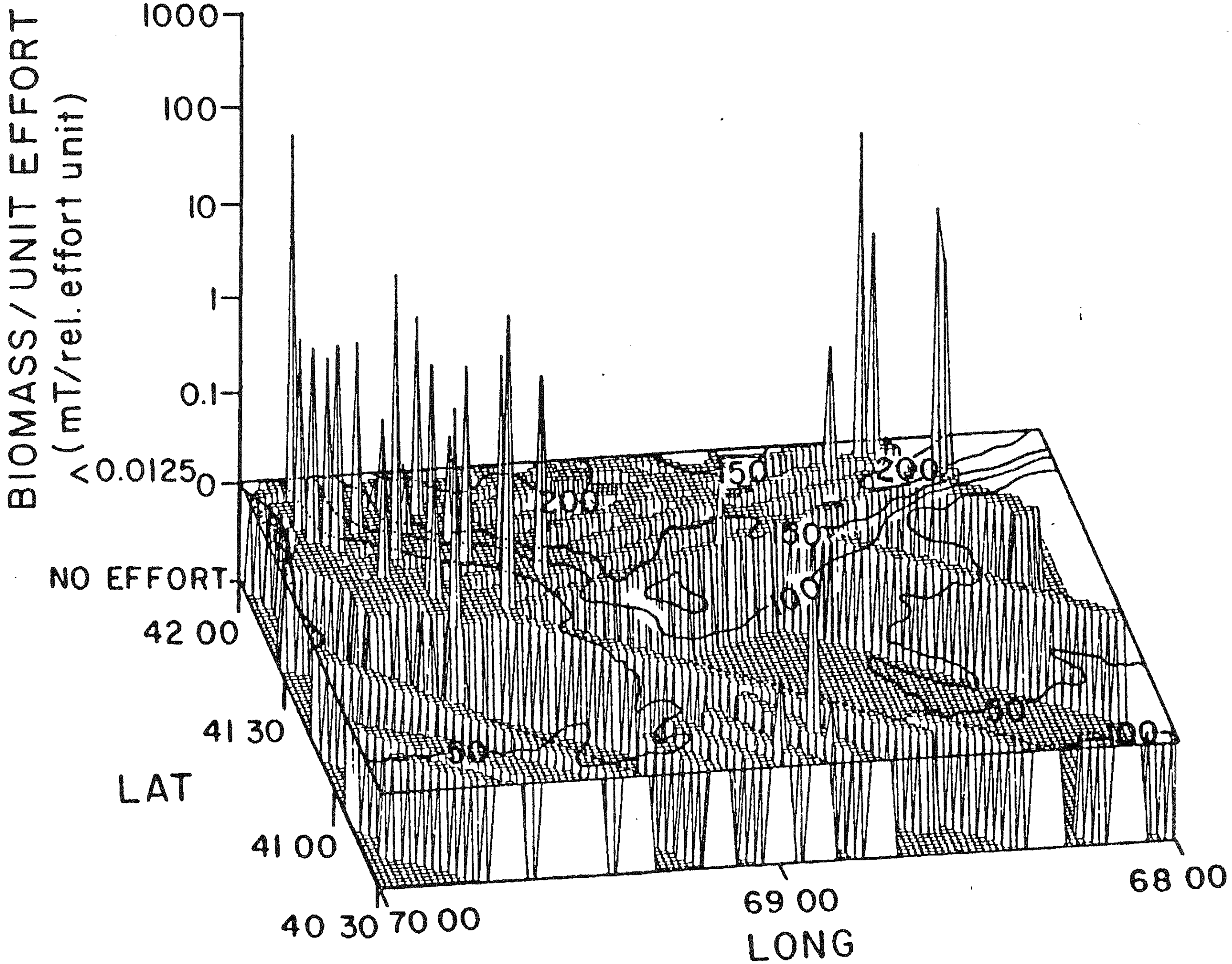

Figure 7. Plot of cetacean biomass sighted per unit of sighting effort by one-minute latitude/longitude quadrat in the Great South Channel area for fall 1979 and 1980. Isobaths in meters.

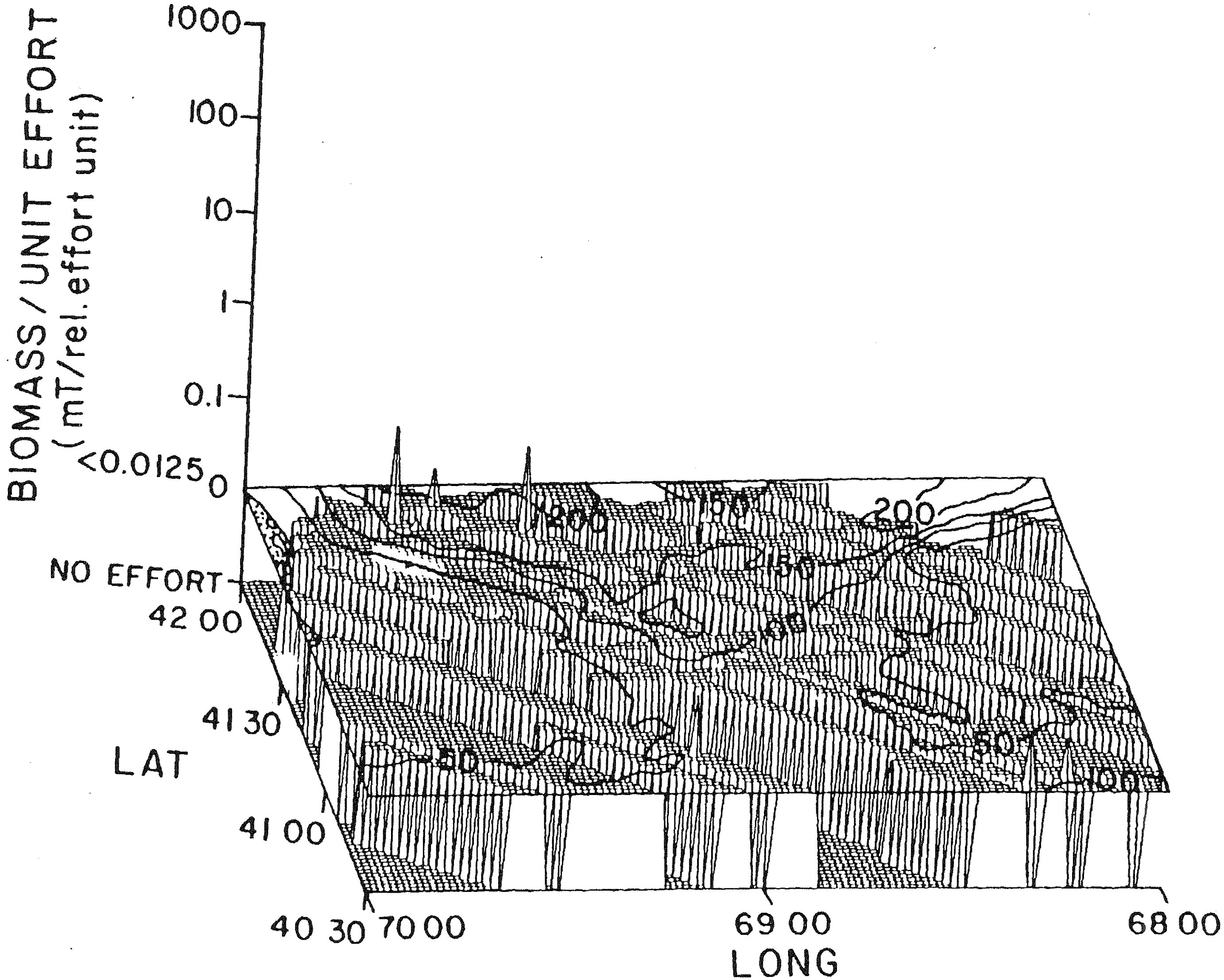

Figure 8. Plot of cetacean biomass sighted per unit of sighting effort by one-minute latitude/longitude quadrat in the Great South Channel area for winter 1979 and 1980. Isobaths in meters.

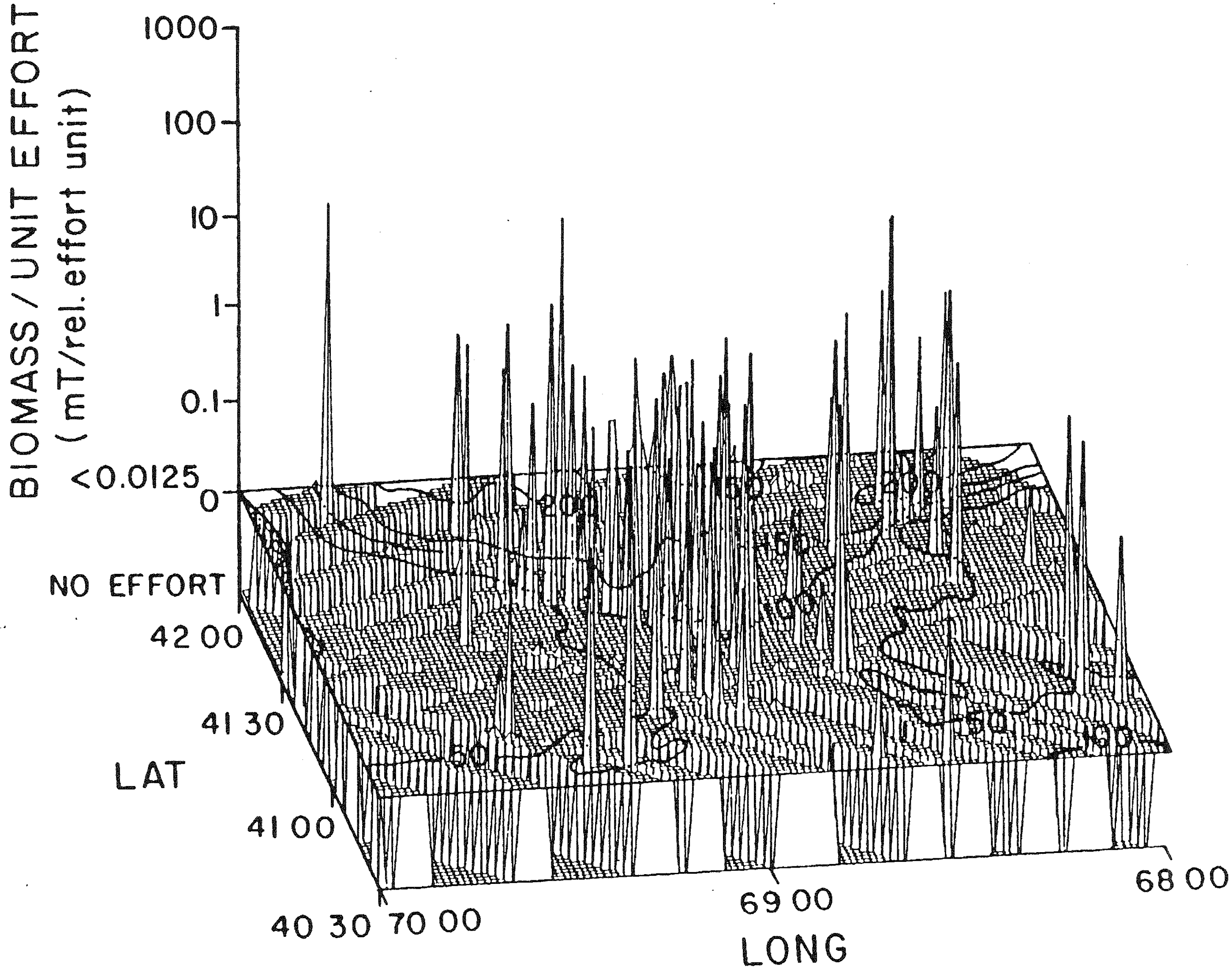

Figure 9. Plot of cetacean biomass sighted per unit of sighting effort by one-minute latitude/longitude quadrat in the Great South Channel area for spring 1981. Isobaths in meters.

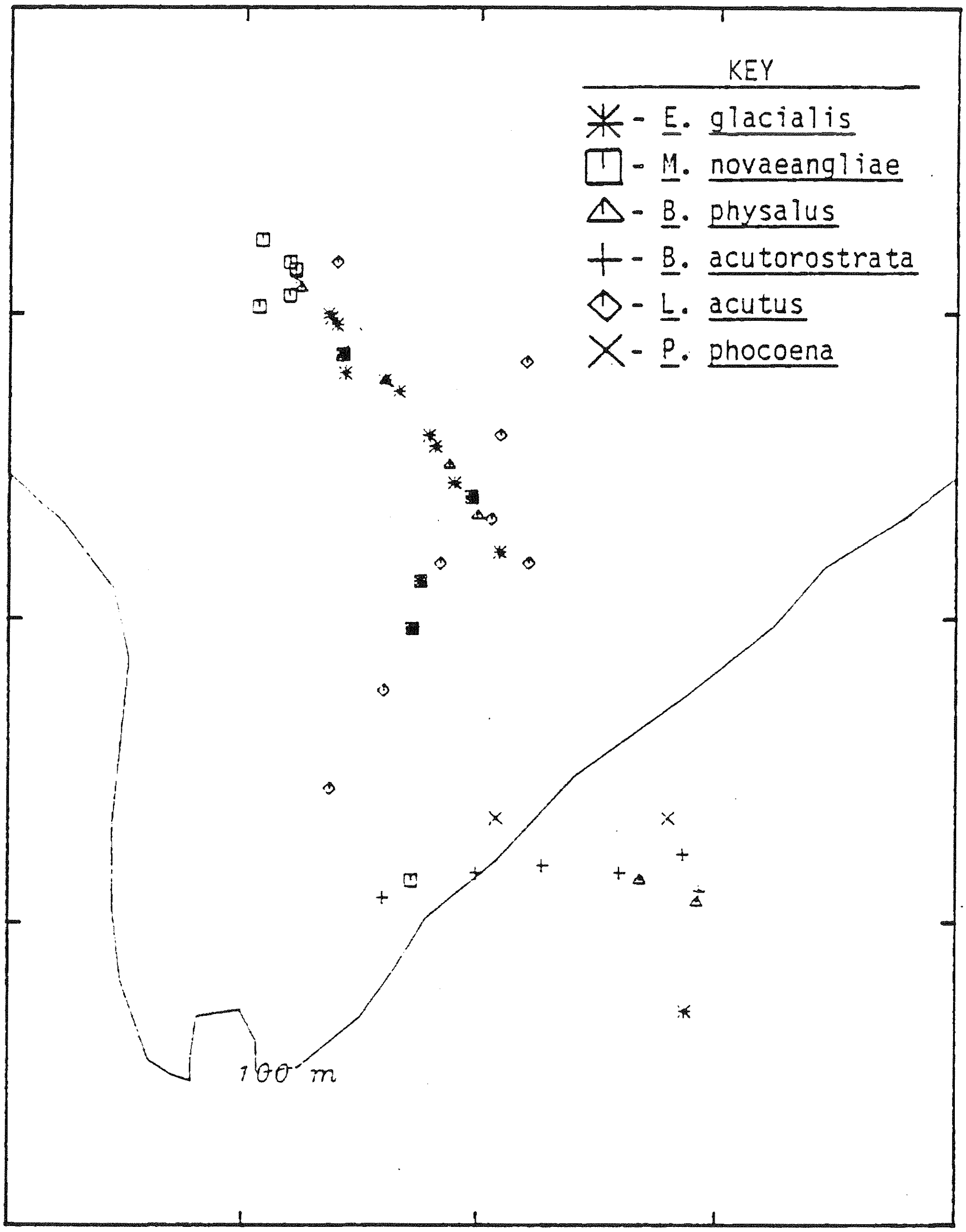

Figure 10. Cetacean sightings made from R/V *Tioga* in the vicinity of a multi-species aggregation in the Great South Channel area, 20 May 1981. The 100 meter isobath is shown.

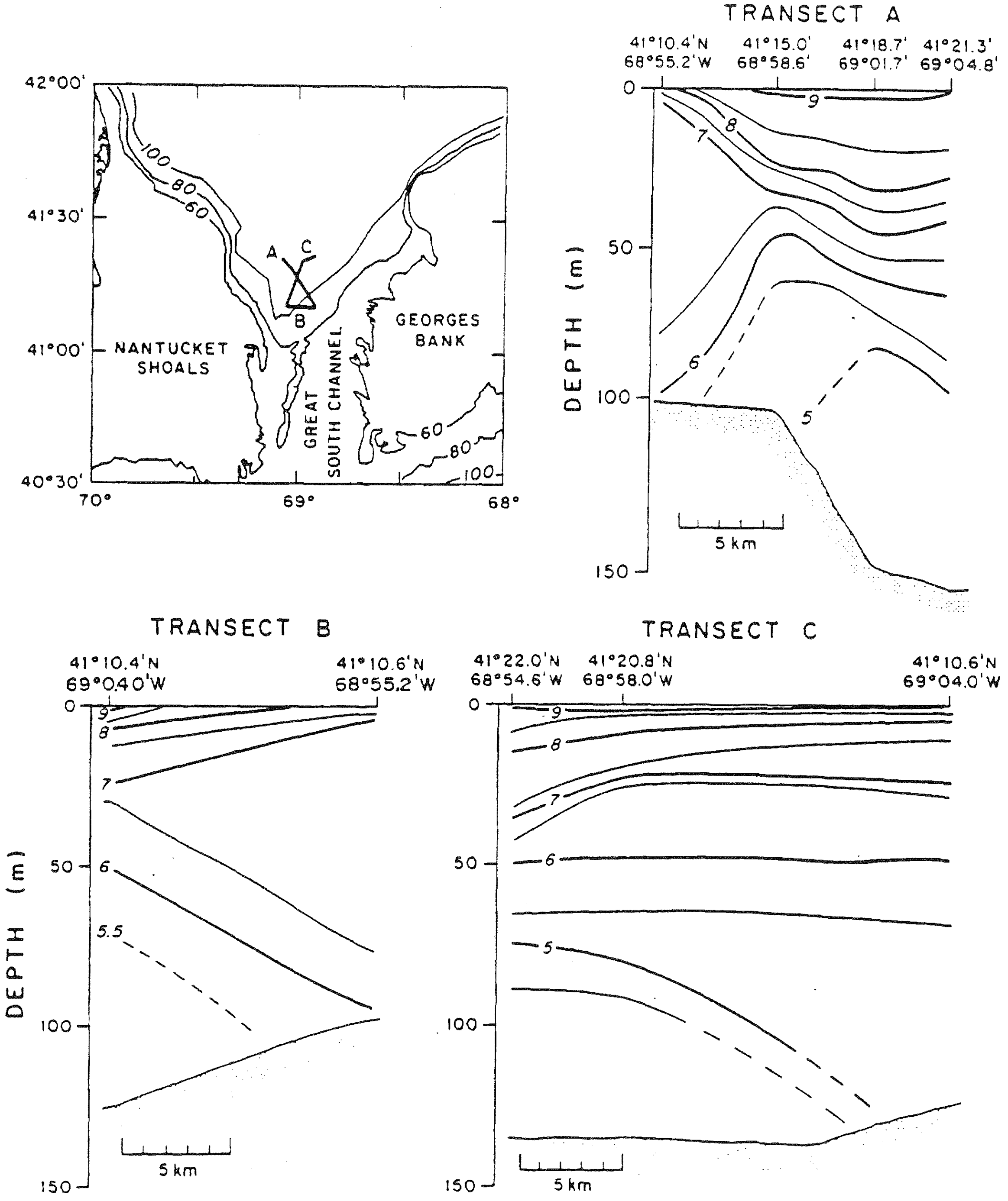

Figure 12. Location of R/V Tioga transects A-C in the Great South Channel area, and associated vertical temperature structure, 20 May 1981.

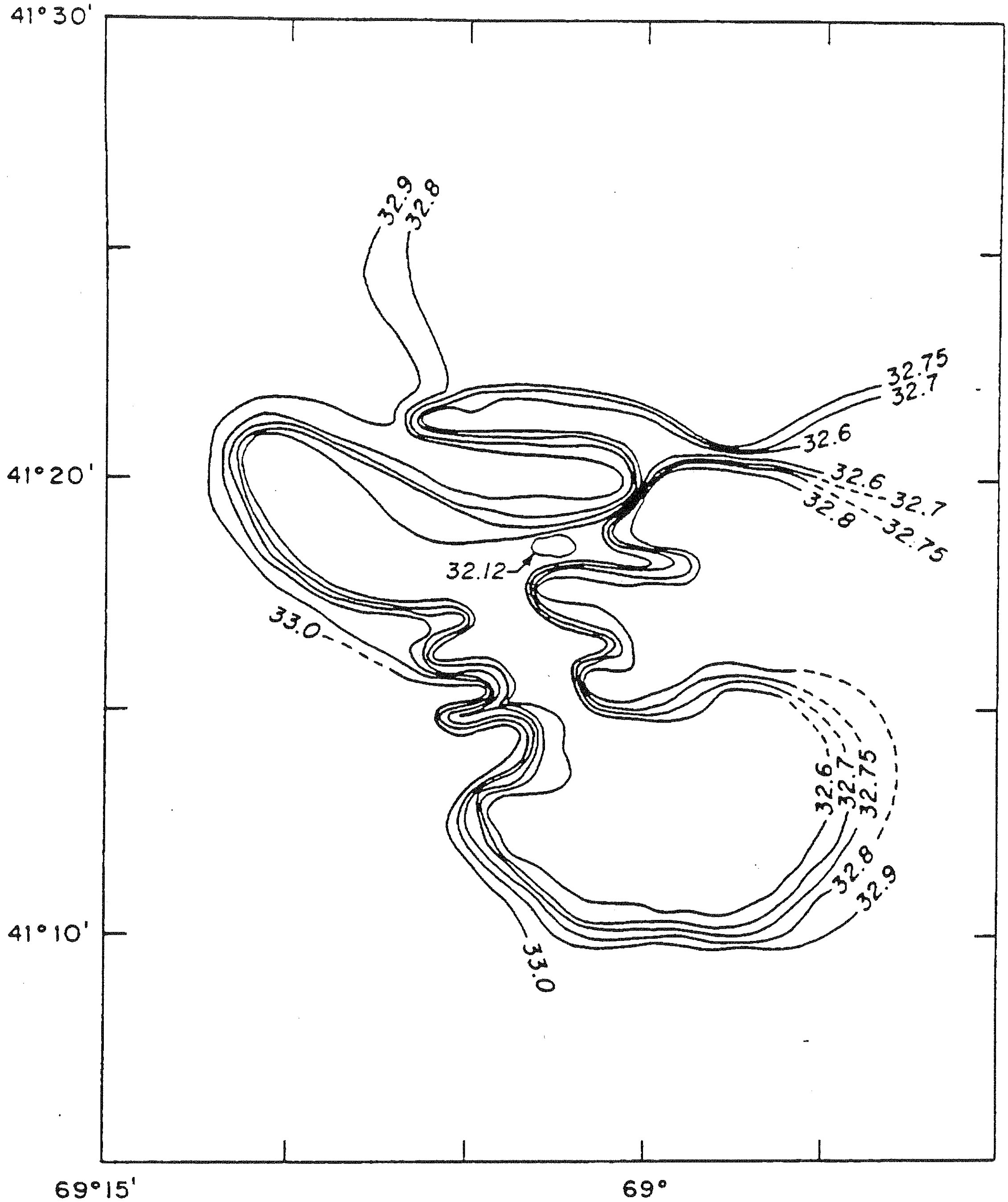

Figure 13. Surface salinity (o/oo) regime in the northern Great South Channel, May 1981.

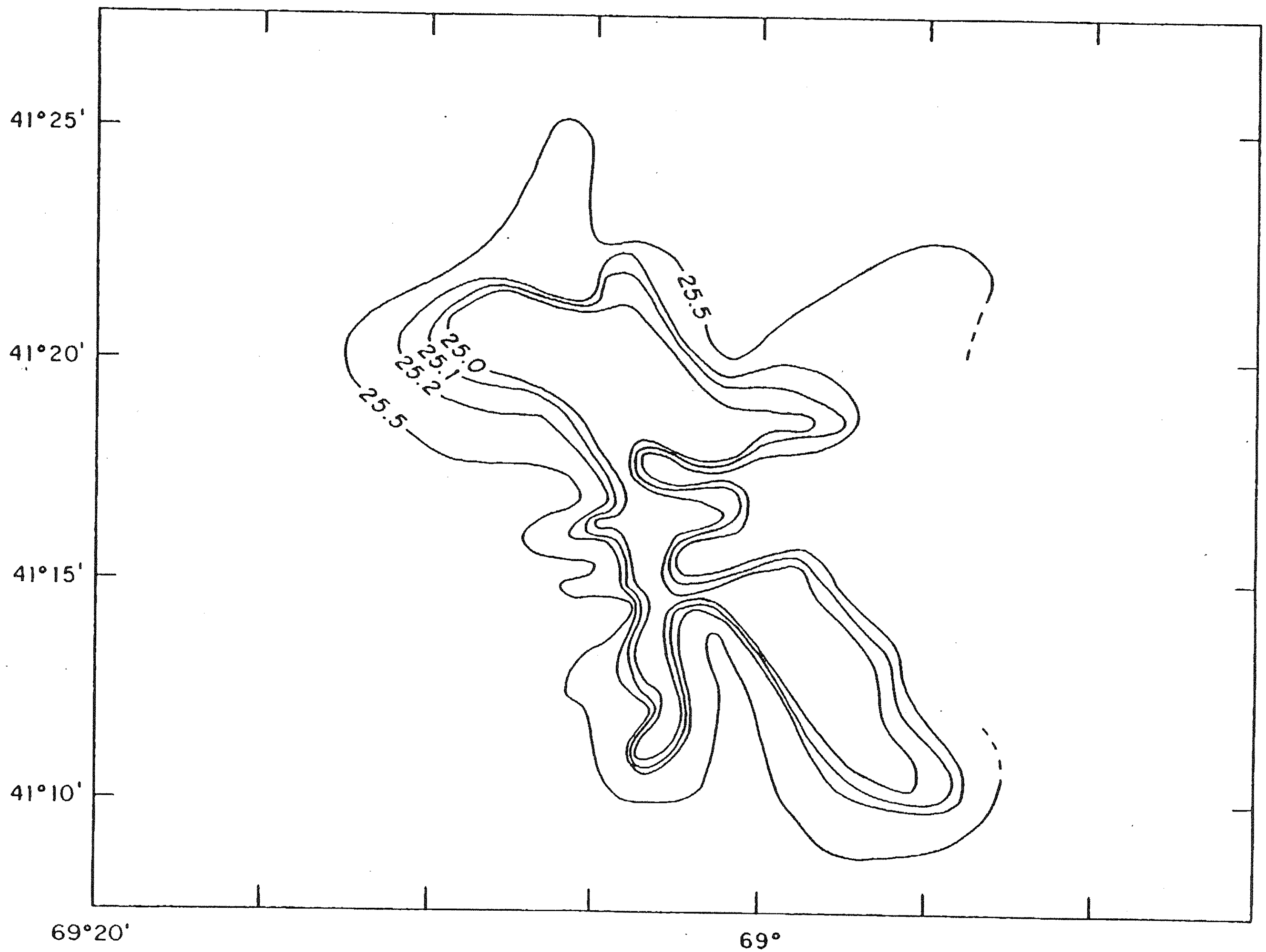

Figure 14. Surface seawater density (sigma-t) regime in the northern Great South Channel, May 1981.

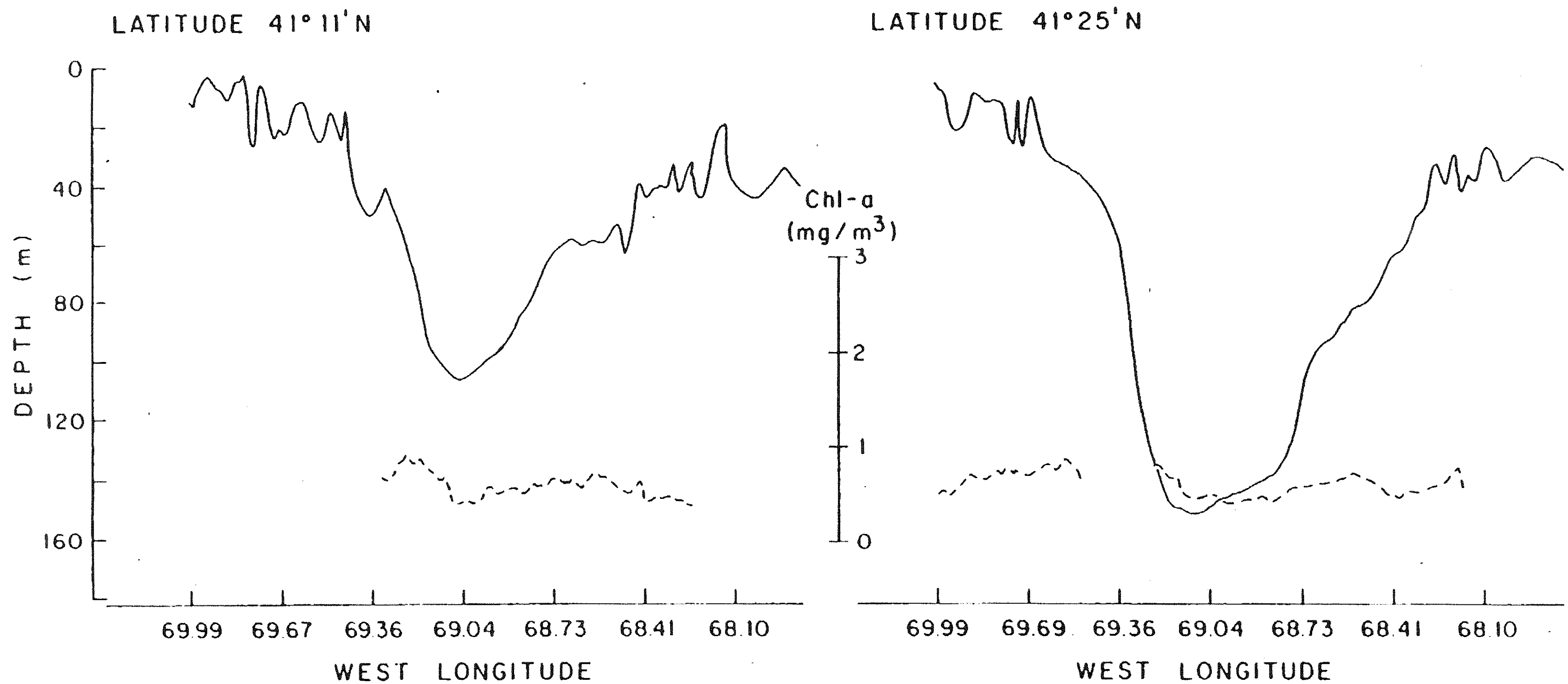

Figure 15. Surface chlorophyll-a measurements along two east-west transects in the Great South Channel area from remote sensors aboard the NASA P-3, 8 May 1981. Chlorophyll values are shown by the dashed lines; solid lines are depth profiles along the same transects.

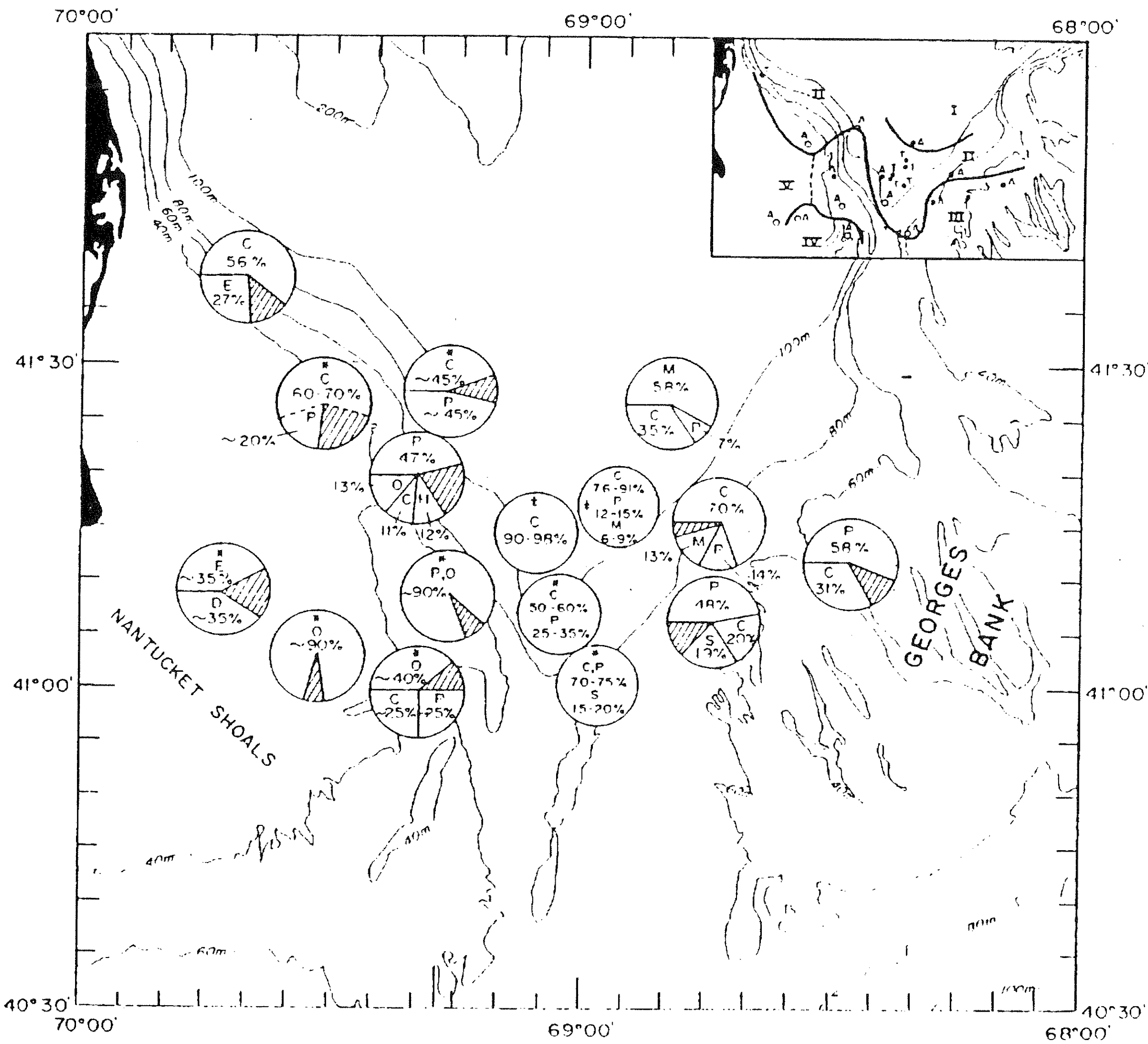

Figure 16. Species composition of zooplankton samples collected in the Great South Channel area, May 1981. Species codes: C=*Calanus finmarchicus*, P=*Pseudocalanus minutus*, M=*Metridia lucens*, O=ostracod, E=euphausiid, D=decapod, S=*Sagitta* sp., H=harpacticoid. *=qualitatively sorted. ǂ>1 station. Inset shows approximate boundaries of zooplankton assemblages I-V. Station codes: A=R/V *Albatross IV*, T=R/V *Tioga*. ● =quantitative, ○ =qualitative.

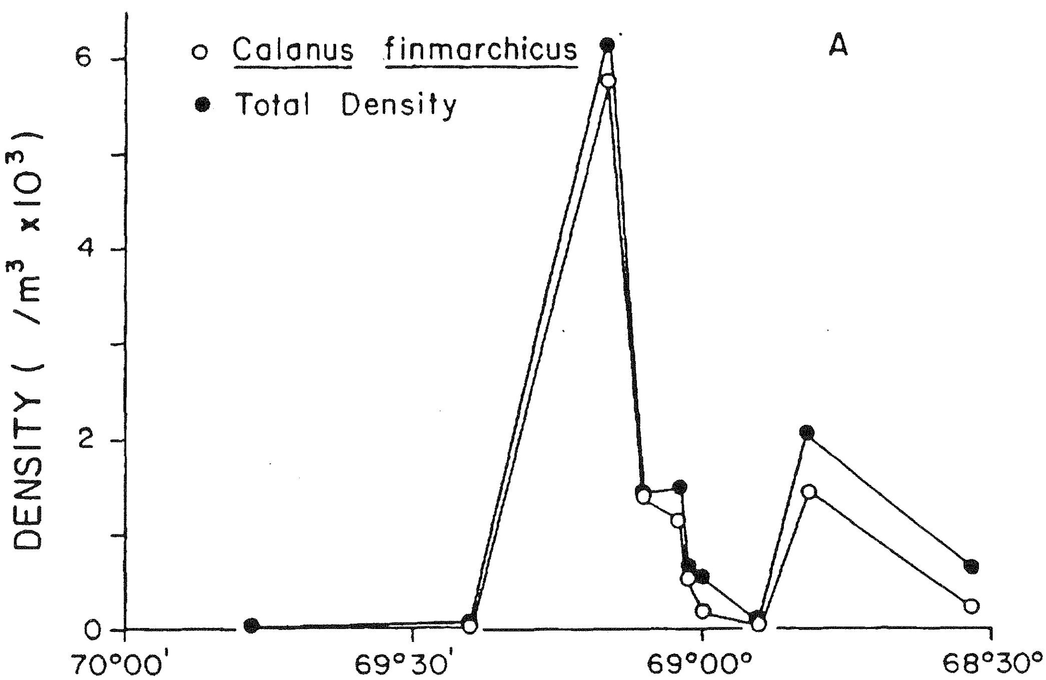

Figure 17. Zooplankton density data for selected sampling stations in a cross section of the Great South Channel, May 1981.

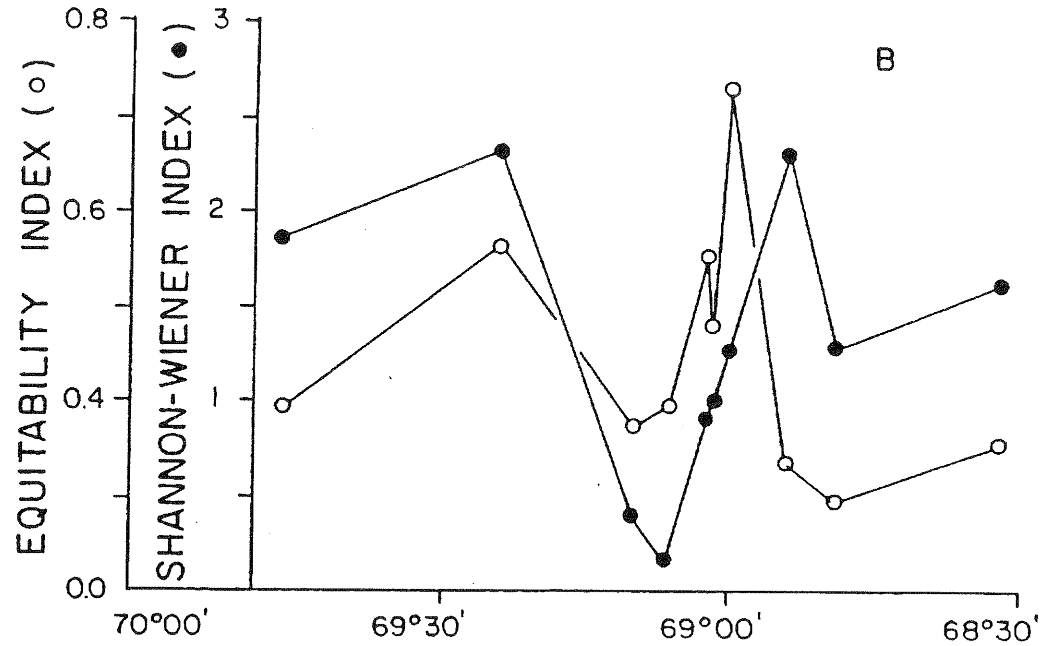

Figure 18. Zooplankton species diversity data for selected sampling stations in a cross section of the Great South Channel, May 1981.

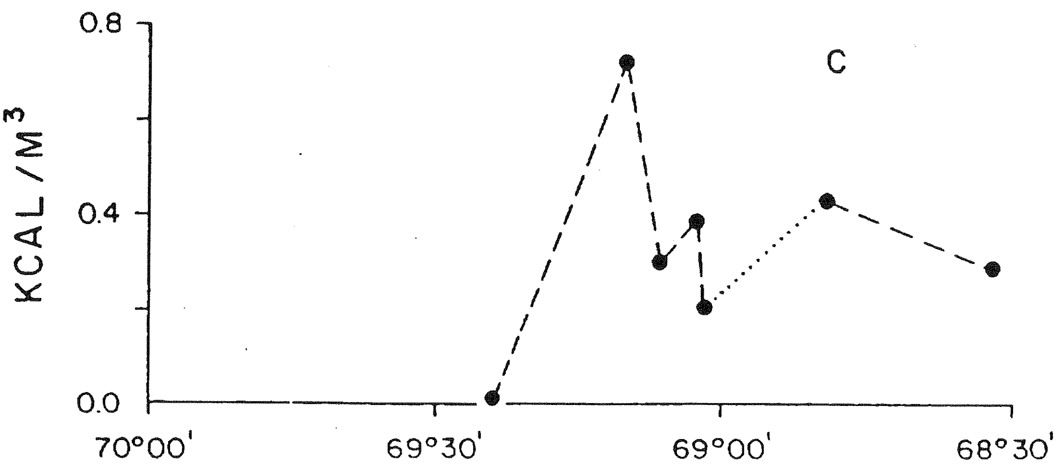

Figure 19. Zooplankton caloric values (Kcal/m^3) for selected sampling stations in a cross section of the Great South Channel, May 1981.

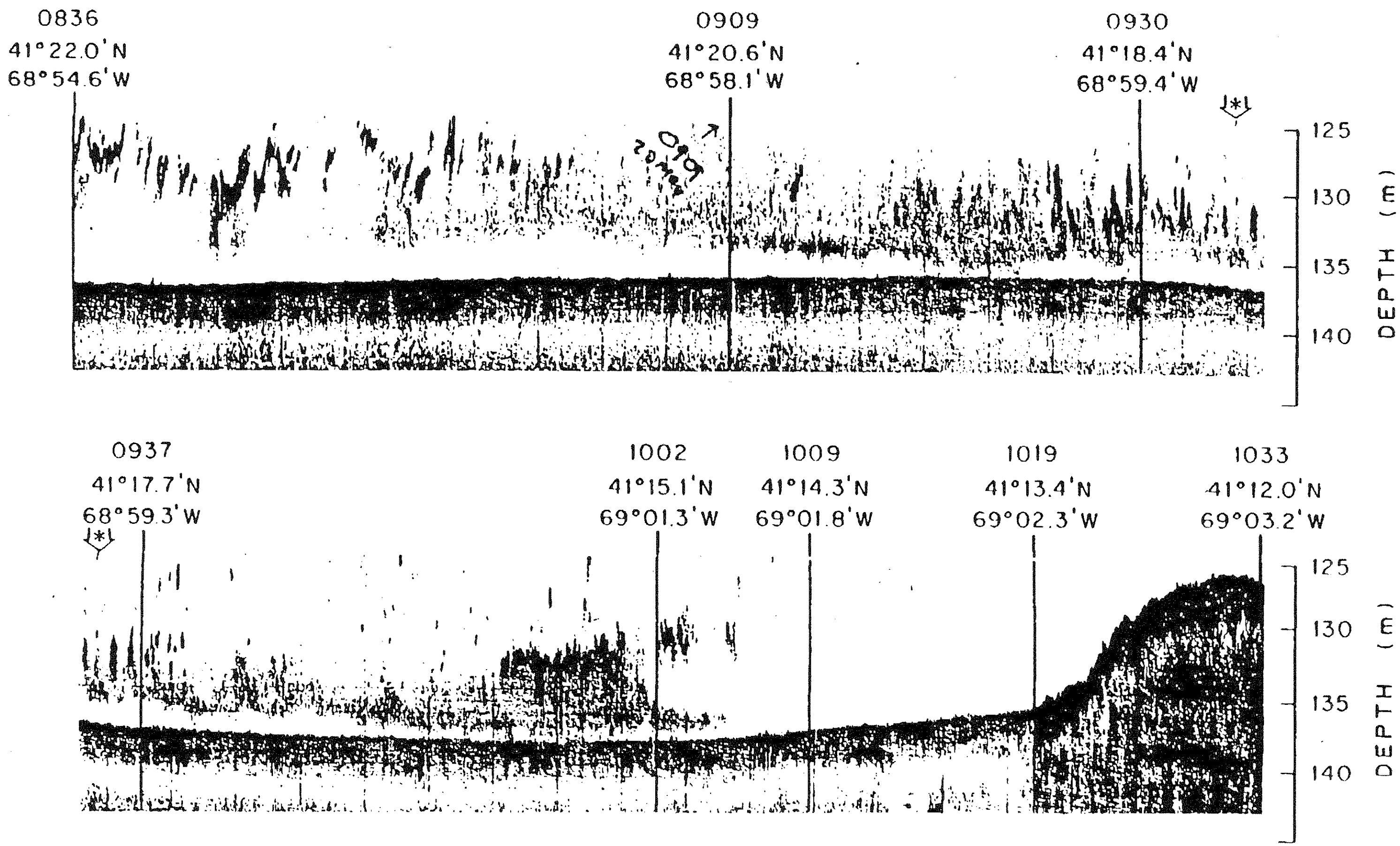

Figure 20. Section of fathometer chart recorded on R/V Tioga, 20 May 1981, showing the presence of a dense layer of presumed zooplankton near the 1002 time reference mark.

Table 1a. Average body weights of identified cetacean species, with literature sources of the values used. In cases where no average weight data could be found, the value was estimated based on body length, and on weights of similar species. These data sources are also shown.

SPECIES	WEIGHT (mT)	SOURCE
Eubalaena glacialis	22.6	Sergeant, 1969
Megaptera novaeangliae	31.9	Sergeant, 1969
Balaenoptera physalus	51.6	Sergeant, 1969
B. borealis	12.5	Sergeant, 1969
B. acutorostrata	4.8	Sergeant, 1969
Physeter catodon	31.5	Sergeant, 1969
Globicephala sp.	1.2	Sergeant, 1969
Grampus griseus	0.5	estimate - Leatherwood et al. (1976)
*Lagenorhynchus*sp.	0.12	see below
L. acutus	0.12	Sergeant et al., 1980
L. albirostris	0.12	assumed same as *L. acutus*
Tursiops truncatus	0.13	Sergeant, 1969
Stenella sp.	0.075	estimate - Perrin, 1975; Perrin et al., 1976; Leatherwood et al., 1976
Delphinus delphis	0.05	Sergeant, 1969
Phocoena phocoena	0.04	Sergeant, 1969

Table 1b. Estimated average body weights for the various unidentified cetacean taxonomic categories, with species included in calculating the estimates.

CATEGORY	WEIGHT (mT)	INCLUDED SPECIES
Unid. whale	25	*P. catodon*, *E. glacialis*, *M. novaeangliae*, *B. physalus*, *B. borealis* *B. acutorostrata*
Unid. large whale	35	*P. catodon*, *E. glacialis*, *M. novaeangliae*, *B. physalus*
Unid. medium whale	8	*B. borealis*, *B. acutorostrata*
Unid. dolphin	0.1	*P. phocoena*, *G. griseus*, *L. acutus* *L. albirostris*, *T. truncatus*, *Stenella* sp., *D. delphis*
Unid. rorqual	25	*M. novaeangliae*, *B. physalus*, *B. borealis*, *B. acutorostrata*
Unid. beaked dolphin	0.05	*T. truncatus*, *Stenella* sp., *D. delphis*
L. acutus or *D. delphis*	0.075	
Unid. dolphin, not *G. griseus*	0.075	*P. phocoena*, *L. acutus*, *L. albirostris*, *T. truncatus*, *Stenella* sp., *D. delphis*
Lagenorhynchus sp. or *T. truncatus*	0.12	

Table 2. Number of sightings and total number of individuals sighted of all cetaceans identified at least to genus during 1979 (including October-December 1978) and 1980 in the Great South Channel area.

SPECIES	1979 SIGHTINGS	1979 INDIVIDUALS	1980 SIGHTINGS	1980 INDIVIDUALS
Eubalaena glacialis	37	64	39	101
Megaptera novaeangliae	132	465	77	318
Balaenoptera physalus	207	776	209	501
B. borealis	1	2	2	4
B. acutorostrata	34	51	28	31
Physeter catodon	2	2	1	2
Orcinus orca	1	1	0	---
Lagenorhynchus spp.	2	9	2	18
L. acutus	89	6113	112	5508
L. albirostris	3	26	3	33
Phocoena phocoena	16	37	77	159
Globicephala spp.	9	197	30	1146
Grampus griseus	0	---	2	11
Delphinus delphis	13	197	5	91
Stenella spp.	4	1180	0	---
S. coeruleoalba	1	5	0	---
Tursiops truncatus	1	13	5	94

Table 3. Number of sightings and total number of individuals sighted of all cetaceans identified at least to genus during the spring of 1981 in the Great South Channel area.

SPECIES	SIGHTINGS	INDIVIDUALS
Eubalaena glacialis	122	383
Megaptera novaeangliae	60	128
Balaenoptera physalus	83	159
B. acutorostrata	15	19
Physeter catodon	1	1
Lagenorhynchus acutus	72	3802
Phocoena phocoena	48	85
Globicephala spp.	7	56
Delphinus delphis	3	28

Table 4. Identifications and counts of individuals in two samples of phytoplankton obtained on 20 May 1981 in the Great South Channel area aboard the R/V TIOGA.

SPECIES	GROUP	CELLS/L
	SAMPLE T52004-A	
Ceratium tripos	dinoflagellate	12
Ceratium longipes	dinoflagellate	18
Ceratium fusus	dinoflagellate	4
Peridinium cerasus	dinoflagellate	22
Gonyaulax orientalis	dinoflagellate	128
Gonyaulax sp.	dinoflagellate	4
Peridinium sp.	dinoflagellate	12
Rhizosolenia styliformis	diatom	68
Coscinodiscus concinnus	diatom	2
Nitzschia pungens	diatom	20
Thalassiothrix frauenfeldii	diatom	1
Pleurosigma sp.	diatom	3
unknown diatoms	diatom	40
unknown flagellates	-----	110
Dictyocha fibula	silicoflagellate	4
Distephanus speculum	silicoflagellate	2
Johannesbaptistia pellucida	blue-green	24
	TOTAL	474
	SAMPLE T52004-C	
Ceratium longipes	dinoflagellate	24
Gonyaulax orientalis	dinoflagellate	4
Peridinium cerasus	dinoflagellate	4
Coscinodiscus sp.	diatom	1
unknown diatoms	diatom	9
Rhodomonas sp.	cryptomonad	12
Cryptomonas sp.	cryptomonad	14
Emiliana huxleyi	coccolithophore	16
unknown coccolithophores	coccolithophore	8
unknown flagellates	-----	12
Agmenellum quadruplicatum	blue-green	28
	TOTAL	131

Table 5. Density and caloric values for zooplankton stations in northern Great South Channel.

Station #	Location		Density (#/m^3)	Caloric value (Kcal/m^3)
AL 8104-26	41°08'	68°54'	90.08	---
29	41°15'	69°24'	50.08	0.01
30	41°15'	69°10'	6181.63	0.72
31	41°15'	68°49'	2084.94	0.431
32	41°23'	69°00'	556.66	---
Al 8104-34	41°14'	68°32'	651.05	0.283
T51405	41°15.6'	69°05.7'	---	---
1509	41°15.1'	69°06.1'	1430.54	0.306
1905	41°12.9'	69°02.3'	1468.20	0.385
2007	41°17.4'	69°01.6'	669.02	0.206
T52801	41°18.8'	69°01.3'	---	---

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ANALYSIS OF

RESPIRATION AND SUBMERGENCE BEHAVIOR

OF CETACEANS IN THE WATERS EAST OF CAPE COD

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Analysis of Respiration and Submergence Behavior of Cetaceans in the Waters East of Cape Cod

INTRODUCTION

Baleen whales are the largest animals on earth and possibly, the least understood. Their inaccessability and the inability of observers to maintain constant contact with them has made cetacean studies difficult. However, careful analysis of some very basic behavioral patterns can lend important insights into the biology of whales.

Diving sequences in whales are not only just simple reflections of an animal's breathing pattern; they are visible, measurable manifestations of a variety of an animal's normal behavioral patterns. For example, diving patterns reflect the whale's physiological capabilities (Kooyman et al., 1981), the relationship between an animal and various pod and/or kin mates, as indicated by the tendency for some animals to surface in unison, and quite possibly, an animal's feeding strategy. Conversely, unusual changes in diving and surfacing patterns may be an outward indication of stress, be it natural or caused by human activities. In recent years researchers have become cognizant that behavioral criteria are an accurate and important measure of an animal's response to sub-lethal pollutants or stresses in their environment (Olla et al, 1980).

Diving patterns are also important to researchers censusing whale populations. An accurate estimate of how many whales of a population can be expected at the surface at any given time is an essential component of any formula for determining whale density and population size based on sighting data (Doi, 1974).

In this report, we describe and discuss the diving and surfacing patterns of three baleen whales: the fin whale (*Balaenoptera physalus*), the humpback whale (*Megaptera novaeangliae*) and the right whale (*Eubalaena glacialis*)

METHODS

Studies of diving and surfacing behavior in right whales, humpback whales and fin whales were conducted in May, 1980, and May 1981. The studies were done in three locations off the coast of Cape Cod, Massachusetts, USA: 1) Stellwagon Bank off the northeast tip of Cape Cod, centered around 42°10'N, 70°15'W; 2) east of the 'elbow' of Cape Cod, centered around 41°40'N, 69°40'W; 3) the Great South Channel, centered 41°20'N, 69°10'W. Whales were observed at each study site in both years, though not all species were observed at each site. Since no differences were observed between sites or years, the data were pooled.

All observations were made during daylight hours from a 21 m vessel, the R/V *Tioga*. During the observation periods it was necessary for the vessel to remain relatively close to the animals in order to record complete sequences of behavior. The exact distance varied depending on sighting conditions, but rarely exceeded 500 m, and was often less than 100 m.

A total of 102.6 h of observations were made on 111 different whales: 24 fin whales, 31 right whales, and 56 humpback whales (Table 1). Individual animals were observed over periods ranging in duration from 13 to 212 min, with a mean of 55 min.

Among the humpbacks and right whales, subjects were chosen so as to best represent various types of social categories, based on their apparent relationships with other animals. Social categories represented were: 1) lone (solitary) animals, 2) cow-calf pairs, 3)adult or adult/juvenile groups of 2-3 individuals, and 4) individuals displaying obvious feeding behavior. Because of the problems inherent in reliably identifying several individuals in a continuous tracking scheme, groups of more than three individuals were not tracked or observed quantitatively. Identification of individual humpbacks was made possible by the distinctive markings on the underside of tail flukes (Katona et al., 1979) and individual variability in dorsal fins and flippers. Right whales were individually identified via their callosity patterns and other distinctive markings (1981 CETAP Report). Fin whales have fewer readily identifiable individual characteristics, and hence, only lone fin whales were included in this study.

A team of observers verbally described and recorded observations on magnetic tape along with reference times by a recorder and timer, while other observers were responsible for verifying individual identification and obtaining photographs.

For subsequent analysis, each onboard recording of behavioral observations was transcribed using a strip chart recorder. Each behavioral event was labelled, and the exact time of occurrence and durations of behavioral acts were determined using the encoded time reference marks.

Our behavioral terminology is as follows. A surface behavioral act was defined as the behavior occurring at the surface following a blow to the point of total submergence in a following dive. A surface behavioral act could incorporate more than one physical movement; for example, a series of flipper slaps all ocurring continuously at the surface without any intervening complete submergence on the part of the whale was considered a single surface behavioral act. Series of behavioral acts were grouped together into surface activity bouts. Single surface behavioral acts within a bout were separated by "short" intra-bout dives; bouts were separated by "long" inter-bout dives . Intra-bout and inter-bout dives were defined quantitatively using a log survivorship plot in which breakpoints between intra-bout and interbout dives were determined by a significant change in the slope of the curve (Fagen and Young, 1978). Any dive shorter than the breakpoint was considered an intra-bout dive; conversely, any dive longer than the breakpoint was an inter-bout dive.

Nonparametric statistics were used in all comparisons due to nonnormal distributions of the data. Since the various distributions of interest were highly skewed, median values were determined in addition to mean values because they provide a better indication of central tendencies. The Kruskal-Wallis test was used for all multiple comparisons among the three species and comparisons of social categories within species (Hollander and Wolfe, 1973).

Because the multiple dive and surface act durations recorded for a given whale were not independent observations, individual animal means for these varaibles were used in all statistical analysis making the statistical tests valid. This had the effect of reducing the working statistical sample size in many of the social categories, e.g., in a Kruskal-Wallis test, N=3 for humpback calves although 51 surface behavior bouts were recorded from the three animals. This makes it difficult to detect real differences between groups.

RESULTS

The whale's behavior consisted of periods of surface activity separated by intervals of time during which the whale was below the surface of the water and not visible to observers. Surface activity consisted of a wide variety of behaviors including blowing, breaching, flippering, spy-hopping, tail (fluke) slapping, feeding, and relatively long periods of apparent resting at the surface.

Observations indicated that all three species exhibited a generalized pattern of two major types of dives. An animal would rise to the surface for a series of blows and surface behavioral acts which were separated by dives of "short" duration, followed by a distinct "long" dive. This pattern of behavior resulted in a temporal separation of surface behavioral acts into clusters or bouts. The breakpoints between "short" intra-bout and "long" inter-bout dives were 24 sec for fin whales, 23 sec for humpbacks, and 30 sec for right whales (Figs. 1-3) based on a significant change in slope of a log survivorship curve.

Within-species Comparisons

Humpback Whales

The comparative surface activity and dive data for humpbacks in the various social categories are found in Table 2. Surface feeding humpbacks had the shortest surface activity bouts, (median duration of 0.44 min). Lone humpbacks, humpbacks in groups of 2-3 animals, and cows had median surface activity bouts of approximately equal duruation (0.67 min, 0.77 min, and 0.81 min, respectively. Calves had the longest surface activity bouts, (median of 2.04 min).

Cows and calves had the shortest inter-bout dive durations (medians of 0.97 min and 1.09 min, respectively). Surface feeding humpbacks and humpbacks in a group of 2-3 individuals had median inter-bout dive durations of 1.34 and 1.39 min, while lone humpbacks had the longest inter-bout dives with a median of 2.22 min.

When expressed as a per cent of total time budget, lone and surface feeding humpbacks spent the least amount of time at the surface, 24% and 27%, respectively. Humpbacks in groups spent 30% of their time at the surface, while cows and calves spent 41% and 65% of their time engaged in surface activity bouts.

Lone humpbacks, surface feeding humpbacks, and humpbacks in groups of 2-3 animals respired at mean rates of 63/h, 66/h, and 68/h. Cows and calves had substantially higher mean respiration rates of 81/h and 83/h.

Right Whales

The comparative surface activity and dive data for right whales in the various social categories are found in Table 3. Right whales in groups of 2-3 had the shortest surface activity bout durations, a median duration of 1.27 min. Cows and calves had median surface activity bout durations of 1.51 min and 1.89 min, while lone right whales had the longest median surface activity bout, 3.25 min.

Right whale calves and cows had the shortest median inter-bout dives, 1.88 min and 1.92 min, respectively. Right whales in groups of 2-3 animals had inter-bout dives of 3.92 min, while lone right whales had significantly longer median inter-bout dives of 7.09 min.

Lone right whales spent the smallest portion of their total time at the surface, a median of 32%. Cows spent 33% of their time at the surfce. Right whales in groups of 2-3 spent a median time of 37%, and calves spent the most time at the surface, a median of 42% of their total time budget.

Respiration rates of right whale cows were lower than all other categories, a mean of only 50/h. Lone right whales respired 62/h, while right whales in groups of 2-3 had a mean of 71/h. Right whale calves had the highest respiration rates, a mean value of 78/h.

Fin Whales

Only lone fin whales were observed since they lacked the necessary individulistic markings that allow observer identification of various whales in groups. Lone fin whale surface activity bouts had a median duration value of 0.86 min; the median inter-bout dive duration was 2.38 min. The median percentage of time spent at the surface by lone fin whales was 25%.

Between Species Comparisons

The surface activity and dive data were combined over all groups within each species and general between-species comparisons were made (Table 4 and 5). The median duration of single surface behavioral acts was 5.0 sec for fin whales, 6.0 sec for humpbacks, and 7.0 sec for right whales. The longest duration of any single surface behavioral act by a fin whale was 1.1 min. Single surface behavioral acts could be much longer in right whales and humpbacks; the longest single behavioral acts being 10.8 min and 21.7 min, respectively.

The median durations of surface activity bouts were similar for fin whale and humpback whales, 0.86 and 0.69 min, respectively. The median duration for right whales was significantly longer, 2.55 min. Surface activity bouts were as long as 24.5 min for fin whales, 21.8 min in humpback whales, and 22.4 min for right whales.

Dive durations ranged from 1 sec in all species to as long as 8.9 min for fin whales, 10.1 min for humpback whales, and 15.8 min for right whales. The median values were only 13 sec, 16 sec, and 14.4 sec, respectively. These low median values were a result of the much higher number of short intra-bout dives than long inter-but dives.

Humpback whales had the shortest median inter-bout dive durations, only 1.53 min. The median inter-bout dive duration for fin whales, 2.38 min, was significantly longer than that found for humpback whales. The median inter-bout dive duration found for right whales, 5.38 min, was significantly longer than that found for either the fin whale or the humpback whale (Table 5).

Surface activity bouts were expressed as a per cent of the animal's total time budget (limited to the observation period). The median values for fin whales (25%) and humpbacks (28%) were not significantly different. The right whales spent significantly more of their total time budget at the surface, 34% than the other species.

Respiration rates, (blows/h) were calculated for all three species. There were no significant differences among the three species. Fin whales respired approximately 70/h, humpback whales 68/h, and right whales 65/h.

DISCUSSION

Although small sample sizes, in particular for cows and calves, imposed statistical problems in comparing various social categories within species, there were some interesting trends in both humpbacks and right whales. In both species, calves spent the highest percentage of their total time budget at or near the surface engaged in surface activity bouts. This was particularly evident for humpbacks, where calves had a median of 65% at the surface. In both species, the calves also had higher respiration rates. This is to be expected, given their smaller size and higher weight-specific metabolic rates (Hill, 1976). In humpback whales the cows' behavior was similar to that of their calves, with high percentages of surface activity and also high respiration rates. This is a result of the cows' close attendance to their calves. Right whale cows did not spend as much time at the surface, nor did they respire as often as their calves. However, the duration of surface activity bouts and dives in right whale cows were much closer to that of their calves than to the other right whale social categories. Thus, it is apparent that the right whale cows were also in close attendance with their calves.

In right whales, lone animals had the longest inter-bout dive durations and spent the least amount of time engaged in surface activity. One possibility as to why these animals were alone and spending greater time underwater is sub-surface feeding. Lone right whales had inter-bout dives on the order of twice as long as any other right whale social category. Right whales feed primarily on calanoid copepods and have been classified as "skimmers," i.e., they gather their prey by swimming for minutes at a time, either above or below the surface, with their mouths agape, skimming the huge numbers of copepods from the water with their baleen (Nemoto, 1970). Previous reports of feeding by right whales have indicated that they most often feed below the surface (Watkins and Schevill, 1976; 1979). Surface feeding by right whales was not observed in our study, but plankton tows taken simultaneously with the right whale observations indicated extremely dense concentrations of Calanus finmarchicus, on the order of 6000/m3. In addition, defecation by the right whales, an obvious indication of recent feeding, was observed repeatedly in our study. We conclude that lone right whales were feeding in their normal pattern below the surface, and hence, the long inter-bout dives.

The values vary in the literature for dive durations for the three species. Doi (1974), reporting on data collected in the Antarctic, gave mean dive durations of 3.7 min for right whales, 4.87 min for fin whales, and 8.13 min for humpbacks. These values for fin whales and humpbacks are both longer than times observed in the current study. Methods and conditions under which the data were collected were not given, so it is not possible to explain the differences between Doi's study and our own.

We have compared our dive data to more recent radio-tagging experiments. Ray et al. (1978) successfully tagged a fin whale in the Gulf of St. Lawrence. Prior to implantation, they estimated that average surface activity bouts lasted 2.43 min, while inter-bout dives averaged 6.33 min. One day later, the whale's surface activity bouts averaged 0.81 min; the inter-bout dives averaged 7.06 min. The surface activity bouts on the second day were nearly identical to our results. However, in both cases, the dive durations were nearly 2-3 times as long. Ray et al. (1978) noted that the whale was obviously transitting from one area to another; at an average speed of over 9 km/h. The fin whales in our study were not transitting, and their shorter inter-bout dives may be a reflection of that difference.

Watkins and co-workers (Watkins, 1981) successfully tagged a fin whale in Icelandic waters and followed its movements for approximately 10 days. Although the report does not give detailed data, a representative plot of some 7 hours of observations was illustrated. We have re-analyzed that segment of data in the same manner as our own data, i.e., with a log survivorship plot. This plot indicated that the breakpoint between intra-bout dives and inter-bout dives was 28 sec, a value nearly identical to our data (24 sec). The median inter-bout dive duration was 1.06 min, the mean inter-bout dive was 1.75 min. Both these values are only slightly shorter than our data, and considerably less than Ray et al.(1978). However, this segment of data from Watkins (1981) was recorded at night and, as will be noted later in the discussion, there are often distinct diel differences in dive behavior.

Watkins et al. (1981) tagged and tracked both fin whales and humpbacks in Prince William Sound, Alaska. Although detailed data are not presented, Watkins et al. (1981) state that usual daytime dives for fin whales were 8-14 min, while nighttime dives were much shorter, 1-2 min. Apparently, the whales stayed near the surface in a quiescent mode at night. Although these figures may be subject to revision if the data on inter-bout dives were objectively defined with a log survivor curve, there was still an apparent diel difference for dive duration. Thus, it is important to realize that any dive data, be considered in light of specific circumstances, and not unreservedly extrapolated to all conditions.

Watkins et al. (1981) noted variable dive times and surface activity patterns for their tagged humpback. During daytime, inter-bout dives were commonly 6-9 min, in duration with a mean of slightly more than 7 min. At night, the humpback was often near the surface, with dive times of 30 sec to 4 min in duration. (Again, these figures were not examined with a log survivorship curve.) Most importantly, however, Watkins et al. (1981) noted that the humpback whales displayed distinctly different behavior patterns and sequences that would change very quickly. This again points out the caution in extrapolating data from a few hours of observation, at a specific time of day, to any overall generalizations for a species or population of whales.

At this point, we must re-emphasize the important differences between the methods used in our and others studies. To our knowledge, this is only the second time in which cetacean dive time data have been treated with log survivorship plots. The first was in Fagen and Young (1978) with blue whale dive data, and there only as an example to illustrate the log survirorship technique. This technique is an objective way of determining breakpoints between intra-bout and inter-bout dives. As is seen in the log survivorship plots (Fig. 2-4), the durations of dives form a continuum; there was no distinct gap between so-called "short" and "long" dives.

Based on our own experience, observers tend to subjectively overestimate the mean lengths of inter-bout ("long") dives. There is a tendency to consider only those dives with unquestionably longer durations, and to ignore those dives which are in the border area between short and long dives. We believe that in the majority of studies considered above, the reported average dive durations are, in fact, an overestimation, and that analysis of the data using log survivorship plots would shorten those average dive times. This suggestion is further supported by our re-analysis of the limited data presented in Watkins (1981), in which the mean and median dive times were much closer to our data than any other study considered.

The overall differences in duration of surface activity bouts and inter-bout dives exhibited by the three species in the current study may have been related to: 1) species' differences in feeding preferences and behaviors; 2) species' differences in metabolic processes; and 3) bias in the data, particularly in the case of fin whales where only lone animals were sampled. Right whales feed on different prey and exhibit different feeding behaviors than fin or humpback whales (Watkins and Schevill, 1976, 1979; Hain et al., 1982). Further detailed studies of feeding behavior on all three species may show a relationship between inter-bout dive duration and feeding strategies. Right whales and humpbacks are much heavier for their length than fin whales (Lockyer, 1976). Basal metabolism demands should be different in the three species for individuals of comparable length (Hill, 1976). Therefore, respiration rates associated with the metabolic rates, which subsequently must be related to dive times and surface activity, may vary among the three species. Only further study will reveal if various social categories of fin whales vary in surface activity and dive durations, and thus alter the overall values for fin whales found in the current study.

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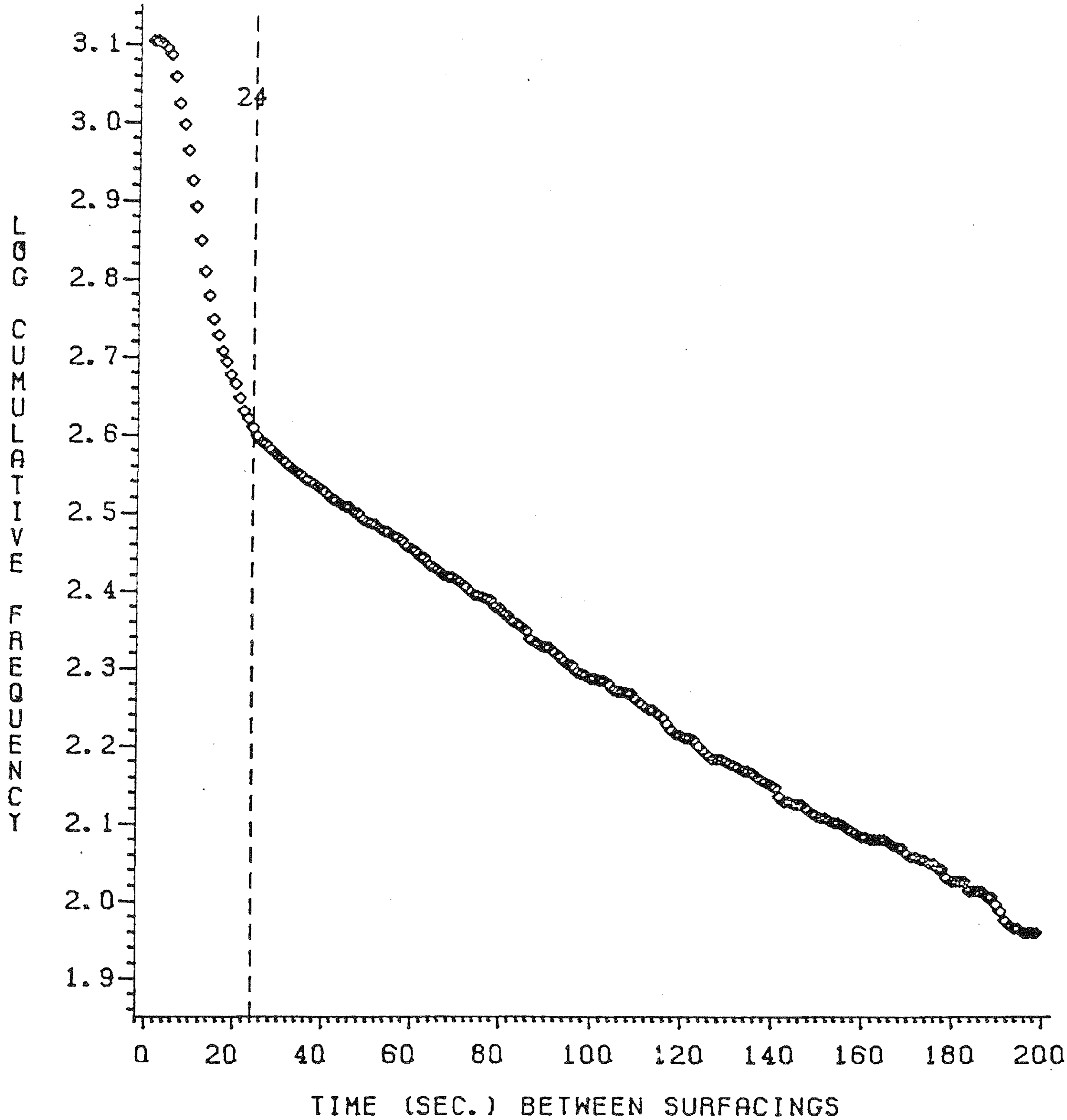

Figure 1. Log survivorship curve of dive durations in fin whales, *Balaenoptera physalus*.

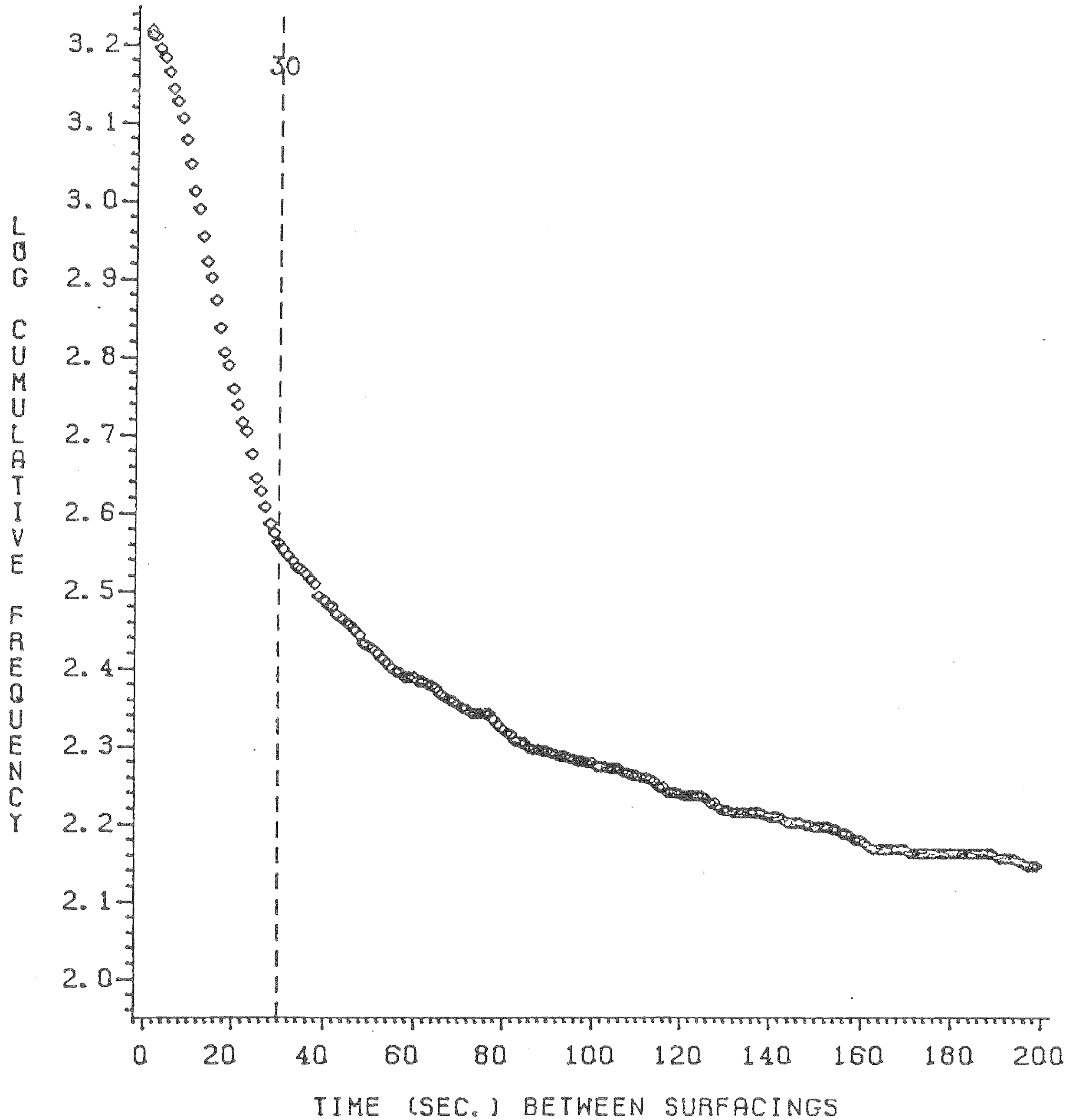

Figure 2. Log survivorship curve of dive durations in right whales, *Eubalaena glacialis*.

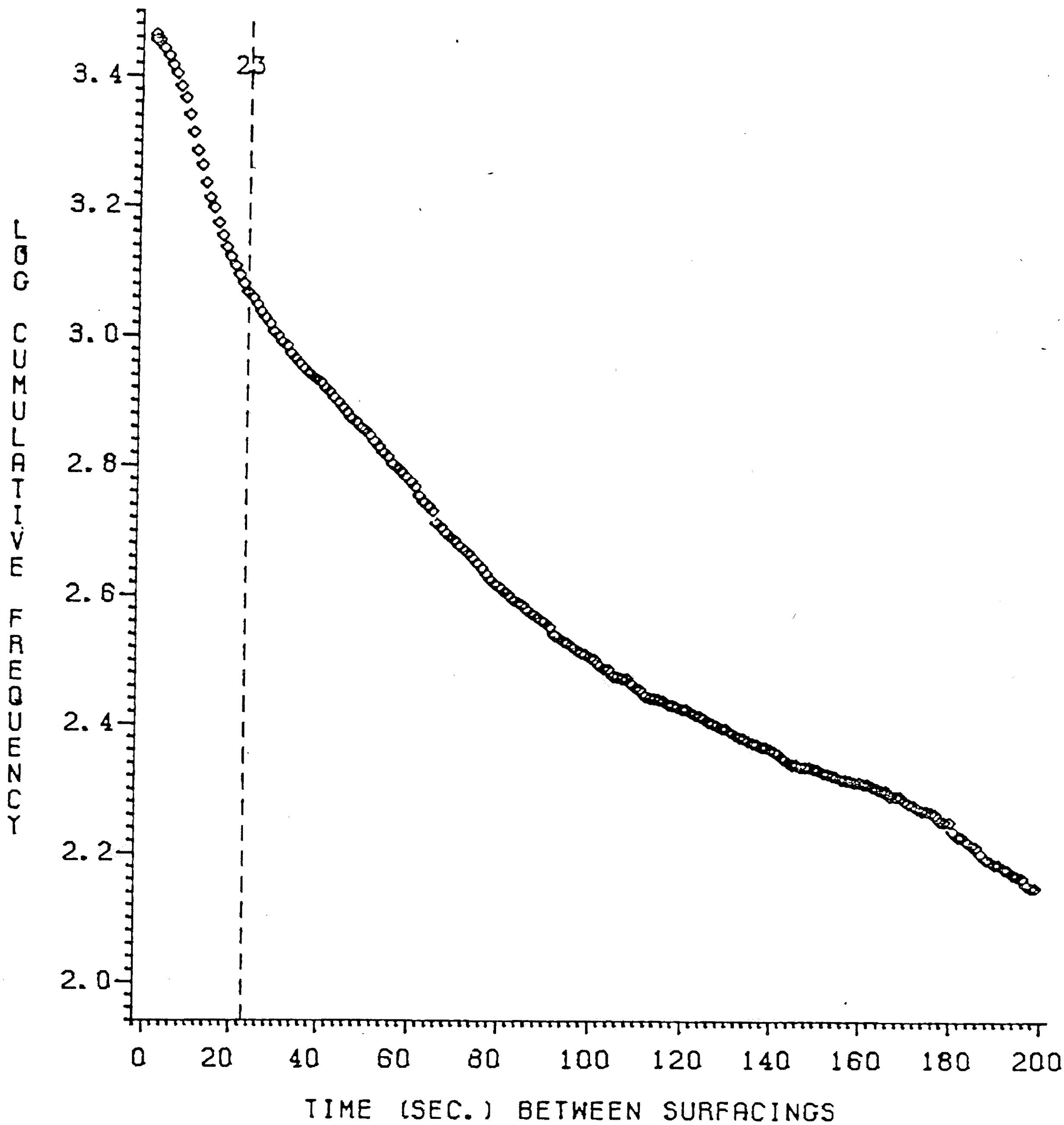

Figure 3. Log survivorship curve of dive durations in humpback whales, *Megaptera novaeangliae*.

Table 1. Total number of whales served in various categories and total number of observation hours for each species of whale.

Species	Lone animals	Adults-juv. in groups	calves	cows	feeding animals	Total	Total hrs
Fin whales	24	-	-	-	-	24	19.7
Humpbacks	25	19	3	3	6	56	45.2
Right whales	17	8	3	3	-	31	37.7

Table 2. Within-species comparisons of humpback social categories: durations of surface activity bouts, duration of inter-bout dives surface activity/total time, and respiration rates.

Duration of Surface Activity Bouts

Category	N1	Eni2	Median	Mean+/-1 S.D.	Mean Rank3	
Calf	3	51	2.04 min	1.86+/-0.54 min	48.7	
Cow	3	81	0.81	0.88+/-0.28	33.7	No
Feeding	6	206	0.44	0.48+/-0.11	17.8	
Group	19	364	0.77	1.04+/-0.92	30.5	
Lone	25	466	0.67	0.86+/-0.64	26.5	

Duration of Inter-bout Dives

Calf	3	50	1.09 min	1.38+/-0.67 min	20.0	
Cow	2	81	0.97	1.51+/-0.96	21.7	
Feeding	6	203	1.34	1.35+/-0.43	22.2	no s
Group	19	360	1.39	1.65+/-1.02	25.4	
Lone	25	451	2.22	2.37+/-1.30	34.2	

Surface Activity as % Total Time

Calf	3	-	65%	58+/-19%	50.0
Cow	3	-	41	39+/-7	43.7
Feeding	6	-	27	28+/-5	24.7
Group	19	-	30	35+/-17	32.9
Lone	25	-	24	27+/-14	21.7

Respiration Rates (Blows/h)

Calf	3	-	83 blows/h	76+/-20 blows/h	33.7	
Cow	3	-	81	74+/-14	33.3	
Feeding	6	-	66	67+/-22	25.7	no s
Group	19	-	68	75+/-20	32.9	
Lone	25	-	63	67+/-26	24.6	

1)Total number of whales observed.

2)Total number of behavioral acts (bouts) summed over all whales in category.

3)Brackets indicate significant differences found using multiple comparisons based on Kruskal-Wallis rand sums test. (a = 0.05).

Table 3. Within-species comparisons of right whale social categories: duration of surface activity bouts, duration of inter-bout dives, surface activity/total time, and respiration rates.

Duration of Surfact Activity Bouts

Category	n1	Eni2	Median	Mean+/-1 S.D.	Mean Rank3
Calf	3	50	1.89 min	1.94=/-0.68 min	12.7
Cow	3	54	1.51	1.85+/-1.48	12.0 no s
Group	8	139	1.27	1.81+/-1.00	10.8
Lone	17	162	3.25	3.20+/-1.39	19.8

Duration of Inter-bout Dives

Calf	3	47	1.88 min	2.50+/-1.31 min	7.0
Cow	3	51	1.92	3.97+/-3.78	11.7
Group	8	133	3.92	3.69+/-2.14	10.4
Lone	17	135	7.09	7.42+/-3.42	21.0

Surface Activity as % Total Time

Calf	3	-	42%	46+/-8%	25.3
Cow	3	-	33	35+/-13	15.3 no
Group	8	-	37	36+/-9	16.5
Lone	17	-	32	35+/-12	14.2

Respiration Rates (Blows/h)

Calf	3	-	78 blows/h	75+/-11 blows/h	22.0
Cow	3	-	50	55+/-13	8.3 no
Group	8	-	71	71+/-12	18.8
Lone	17	-	62	66+/-14	15.0

1) Total number of whales observed.

2) Total number of behavioral acts (bouts) summed over all whales in category.

3) Brackets indicate significant differences found using multiple comparisons based on Kruskal-Wallis rank sums test. (a = 0.05)

Table 4. Descriptive statistics for the duration of individual acts of surface activity and dive intervals summed over all whales for each species.

Duration of Single Surface Behavior Acts

Species	N1	Median	Mean +/- 1 S.D.	Range
Fin whales	1214	5.0 sec	5.3 +/- 3.1 sec	1 sec-1.1 min
Humpbacks	2936	6.0	11.7 +/- 39.2	1 sec-21.7 min
Right whales	1683	7.0	20.5 +/- 44.7	1 sec-10.8 min

Duration of Dives

Species	N1	Median	Mean +/- 1 S.D.	Range
Fin whales	1199	13.0 sec	49.1 +/- 82.4 sec	1 sec-8.9 min
Humpbacks	2911	16.0	44.0 +/- 59.2	1 sec-10.1 min
Right whales	1655	14.4	60.8 +/- 141.7	1 sec-15.8 min

1) N refers to the number of individual behavioral acts summed over all individual whales observed.

Table 5. Between-species comparisons for duration of surface activity bouts, duration of inter-bout dives, surface bouts/total time, and respiration rates.

Duration of Surface Activity Bouts

Species	N1	Eni2	Median	Mean +/- 1 S.D.	Mean Rank
Fin whales	24	412	0.86 min	0.88 +/- 0.52 min	44.5
Humpbacks	56	1168	0.69	0.94 +/- 0.74	44.0
Right whales	31	405	2.55	2.58 +/- 1.38	86.5

Duration of Inter bout Dives

Fin whales	24	397	2.38	2.60 +/- 1.05	61.1
Humpbacks	56	1145	1.53	1.92 +/- 1.15	39.6
Right whales	31	366	5.38	5.65 +/- 3.53	81.7

Surface Activity as % Total Time

Fin whales	24	-	25%	25 +/- 9%	40.6
Humpbacks	56	-	28%	32 +/- 16	54.0
Right whales	31	_	34%	36 +/- 11	71.5

Duration Rates (Blows/h)

Fin whales	24		70bls/h	67 +/- 19 blows/h	54.9
Humpbacks	56		68	71 +/- 22	57.5 no
Right whales	31		65	67 +/- 14	54.3

1) Total number of whales observed. Since repeated observations of activity from a given whale were not independent, all observations from a given whale were averaged and the mean then utilized as the experimental unit.

2) Total number of behavioral acts (bouts) summed over all whales in category.

3) Brackets indicate significant differences found using multiple comparisons based on Kruskal-Wallis test. (a = 0.05)

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16. Abstract (Limit: 200 words)

The 1982 CETAP report presents the cumulative and summarized results from field studies which began in November of 1978 and concluded in January of 1982. Program objectives were: 1) to determine which species of marine mammals and marine turtles inhabit and/or migrate through the study area; 2) to identify, delineate, and describe areas of importance (feeding, breeding, calving, etc.) to marine mammals and marine turtles in the study area; 3) to determine the temporal and spatial distribution of marine mammals and marine turtles in the study area; 4) to estimate the size and extent of marine mammal and turtle populations in the study area; 5) to emphasize the above items (1-4) for those species classified as threatened or endangered by the Department of Interior and Department of Commerce.

The study area was defined to be the waters overlying the U.S. Outer Continental Shelf between Cape Hatteras, North Carolina, and Nova Scotia, Canada. It is characterized by many submarine canyons, shoals, submarine banks, diverse depth gradients, proximity to a major ocean current (the Gulf Stream), numerous adjoining bays and sounds, and a large semienclosed body of water--the Gulf of Maine.

17. Document Analysis a. Descriptors

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